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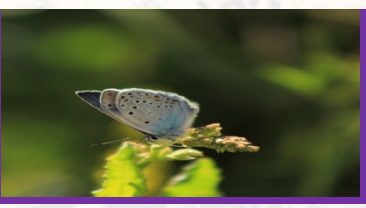

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Upper Extremity Surgery: Tissue Oxygenation and Block Quality in Infraclavicular Block with Different Arm Angles

Üst Ekstremite Cerrahisi: Farklı Kol Açıları ile uygulanılan İnfraklaviküler Blokta Doku Oksijenasyonu ve Blok Kalitesi

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Abstract

Background: The aim of this study was to evaluate tissue oxygenation and block quality using Near Infrared Spectroscopy (NIRS) in infraclavicular block application performed at different arm angles under ultrasonography (USG) guidance in upper extremity surgeries.

Materials and Methods: The study included patients aged 18-65 years, in the ASA I-II risk group, scheduled for unilateral upper extremity (hand, wrist and forearm) surgery, who accepted the infraclavicular block. The arm was abducted at 0°, 45° and 90° respectively and hemodynamic data, StO2, SpHb, PI value, rSO2 and body temperature were recorded from both the blocked and the other extremity at 0, 5, 10, 15, 20, 25 min before and after the block. **Results**: The study included 91 patients who met the inclusion criteria. It has been observed that 90° abduction of the arm with the forearm in the anatomical position during infraclavicular block application increases USG visibility and provides better ease of application. There was a significant increase in StO2, rSO2, PI value and body temperature between the blocked and unblocked extremity in the same patient ($p<0.05$). There was a difference in StO2, rSO2, PI value and body temperature between patients with successful block (n:85) and patients with failed block (n:6) ($p<0.05$). StO2 and rSO2 were significantly higher after 5 minutes, PI value after 10 minutes and body temperature change after 25 minutes between the successful and unsuccessful groups ($p<0.05$).**Conclusions:** We think that 90° abduction of the arm while the forearm is in the anatomical position during infraclavicular block application increases USG visibility and provides better ease of application, and StO2, rSO2, PI value and body temperature measurements can be used to evaluate block success.

Keywords: Infraclavicular block, Near Infrared Spectroscopy (NIRS), Tissue oxygenation, Noninvasive total hemoglobin monitoring (SpHb), Perfusion Index (PI)

ÖZ

Amaç: Bu çalışmanın amacı üst ekstremite cerrahilerinde ultrasonografi (USG) eşliğinde farklı kol açılarında yapılan infraklaviküler blok uygulamasında Yakın Kızılötesi Spektroskopi (NIRS) kullanılarak doku oksijenasyonu ve blok kalitesinin değerlendirilmesidir.

Gereç ve Yöntem: Çalışmaya 18-65 yaş arası, ASA I-II risk grubunda, tek taraflı üst ekstremite (el, el bileği ve önkol) cerrahisi planlanan ve infraklaviküler bloğu kabul eden hastalar dahil edildi. Kol sırasıyla 0°, 45° ve 90°'de abduksiyona getirildi ve hemodinamik veriler, StO2, SpHb, PI değeri, rSO2 ve vücut sıcaklığı bloktan önce ve sonra 0, 5, 10, 15, 20, 25. dakikalarda hem blok yapılan hem de diğer ekstremiteden kaydedildi.

Bulgular: Çalışmaya dahil edilme kriterlerini karşılayan 91 hasta dahil edildi. İnfraklaviküler blok uygulaması sırasında ön kol anatomik pozisyonda olacak şekilde kolun 90° abdüksiyonunun USG görünürlüğünü arttırdığı ve daha iyi uygulama kolaylığı sağladığı görüldü. Aynı hastada bloklu ve bloksuz ekstremite arasında StO2, rSO2, PI değeri ve vücut sıcaklığında anlamlı artış vardı ($p<0,05$). Başarılı blok uygulanan hastalar (n:85) ile başarısız blok uygulanan hastalar (n:6) arasında StO2, rSO2, PI değeri ve vücut sıcaklığında fark vardı ($p<0,05$). Başarılı ve başarısız gruplar arasında StO2 ve rSO2 5. dakikadaki, PI değeri 10. dakikadaki ve vücut sıcaklığı değişimi 25. dakikadaki anlamlı yüksekti ($p<0,05$). **Sonuç:** İnfraklaviküler blok uygulaması sırasında ön kol anatomik pozisyonda iken kolun 90° abdüksiyonda olmasının USG görünürlüğünü arttırdığını ve daha iyi uygulama kolaylığı sağladığını, StO2, rSO2, PI değeri ve vücut ısısı ölçümlerinin blok başarısını değerlendirmede kullanılabileceğini düşünüyoruz.

Anahtar kelimeler: İnfraklaviküler blok, Near İnfrared Spektroskopisi, Doku oksijenizasyonu, Noninvaziv total hemoglobin monitörizasyonu, Perfüzyon İndeksi

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Highlights

- In upper extremity surgeries, infraclavicular block application with ultrasonography is a frequently preferred method because it is considered a safe anesthesia method.
- Near Infrared Spectroscopy is used as a device for tissue oxygenation and block quality.
- Tissue oxygenation was measured using Near Infrared Spectroscopy while the block was applied.

Introduction

Regional anesthesia (RA) is defined as the temporary blocking of nerve functions in certain parts of the body without inducing a state of unconsciousness and elimination of pain sensation (1).

The fact that airway reflexes are preserved and the risk of aspiration is very low, analgesia continues in the postoperative period, hospital stay is short and it is low cost makes regional anesthesia superior to general anesthesia (2).

Infraclavicular block performed under ultrasonography (USG) guidance in upper extremity surgeries is a brachial plexus block technique that is easy to perform and can be used in day surgery (3). Different methods such as modified raj technique, coracoid block technique, vertical block technique and lateral sagittal block technique have been described in practice (4).

The position of the arm at different angles during infraclavicular block affects the placement and position of the medial, lateral and posterior cord nerves (5). Wang et al. investigated the optimal upper arm position in infraclavicular brachial plexus block via coracoid approach and reported that the optimal position was 90° abduction of the upper arm with external rotation of the shoulder. In this position, the brachial plexus is closer to the skin and further away from the pleura compared to other angles (6).

Various methods have been used to evaluate block success. Holmenn scale, Bromage scale, Modified bromage scale, Lovett Rating scale are the most commonly used scales to evaluate motor block (7). These tests are subjective tests and require good patient communication, and the evaluations are different can be interpreted (8). Objective evaluation methods eliminate these negativities (9).

In peripheral nerve blocks, local vasodilatation, increased local blood flow, increased skin temperature and skin vasoconstrictor reflexes occur as a result of blockade of sympathetic nerve fibers in the applied area. These changes indicate a successful and adequate peripheral nerve blockade (10). In the literature, various methods have been described to quantitatively evaluate block-related autonomic innervation (11). NIRS, PI, Peripheral Flow Index (PFI), color Doppler sonography, electrical resistance changes in the skin, noninvasive tissue hemoglobin measurement and body temperature measurement are among these methods (12,13,14).

NIRS is a noninvasive method that measures tissue oxygen saturation with a sensor placed on the skin (15). Oxygen saturation of subcutaneous tissue may be affected as a result of decreased sympathetic activity in regional anesthesia. Based on this principle, the success of peripheral nerve blocks can be evaluated non-invasively and rapidly. Changes in tissue oxygen saturation measured by NIRS can give us an idea about the intensity and depth of the block (16). Perfusion index (PI) can be measured noninvasively by pulse oximetry and provides quantitative information about peripheral perfusion (11,12,17). Minville et al. reported that skin temperature measured with a simple infrared thermometer after infraclavicular brachial plexus blockade is a reliable, simple and early indicator of a successful nerve block (18).

In this study, we planned to investigate the success of USG-guided infraclavicular block application in upper extremity surgeries in evaluating tissue oxygenation and block quality according to different arm angles using Near Infrared Spectroscopy (NIRS), perfusion index (PI) and Noninvasive total haemoglobin monitoring (SpHb).

Material and Methods

Study design

It was conducted with 91 patients aged 18-65 years, in the American Society of Anesthesiologists (ASA) I, II group, undergoing upper extremity (hand, wrist and forearm) surgery and who accepted the infraclavicular block. Of a total of 91 patients who underwent usg-guided infra-clavicular application, block failed in 6 patients. Patients in whom infraclavicular block was contraindicated, uncooperative patients, patients with renal insufficiency, patients with hepatic insufficiency, pregnant and lactating women, and ASA III, IV, V group patients were excluded from the study. Patients who were accepted to the study were informed verbally and in

writing about the anesthesia method to be applied for the surgery to be performed and the thesis study, and their written informed consent was obtained.

Standard monitoring with noninvasive arterial blood pressure (BP), electrocardiography (ECG) and pulse oximetry (SpO2) was performed in the preoperative preparation room before the infraclavicular block. All patients received midazolam 0.02-0.03 mg/kg IV. A regional oximetry probe (rSO2 sensor) (Masimo, Irvine, CA, USA) was placed on the inside of the wrists of the upper extremities of the patients, both in the upper extremity where the block was to be performed and in the upper extremity where the block was not to be performed, to measure peripheral tissue oxygen saturation. A pulse oximeter sensor (R1 25 SpHb SpO2 SpMet Adult Pulse CO-Oximeter Adhesive Sensor) was placed on the 3rd finger of both hands of the patients to measure PI value and SpHb. These sensors and probes were used to record data from the Masimo IC model: RDS7A device and recorded the data. A NIRS probe (Inspectra™ StO2 Spot Check- Model 300 (Hutchinson Technology Inc., Hutchinson, MN, USA) was placed on the tenar parts of both upper extremities of the patients for StO2 measurement and recordings were taken. Heart rate (HR), systolic and diastolic blood pressure values, oxygen SpO2, StO2, SpHb, PI, rSO2 and body temperature (Mesilife DT-8806 Infrared Thermometer) were measured at the midpoint of the inside of both wrists 5 min before the block (pre-anesthetic value).

A 22 G, 50 mm, insulated facet type needle (B.Braun Stimuplex, Melsungen AG, Germany) was used for the block. Local anesthetic solution was prepared with 15 mL of 0.5% bupivacaine and 15 mL of 2% lidocaine. The block was performed with the Lateral Sagittal Infraclavicular Brachial Plexus Block (LSIB) technique described by Klaastad et al. (19). Nerve blocks were performed and evaluated by the same person with at least four years of experience.The practitioner was positioned at the head of the patient, the forearm was in the anatomical position on the side to be blocked, the arm was abducted 0°, 45° and 90° respectively, and the plexus-skin distance and the appearance of the axillary arteries, veins and cords were recorded as poor (0), fair (1) and good (2) for ease of visualization on USG. For the arm abduction angle, the patients were randomly divided into 3 groups: 21 patients in the 0° group, 35 patients in the 45° group and 35 patients in the 90° group. After the arm was angled, the area to be blocked was sterilized with povidine iodine. The block was performed with in-plane technique using an ultrasound device (Esaote My Lab 30 Gold, Italy) and a linear probe (10-18 MHz). The probe was placed medial to the coracoid process and oriented in the parasagittal plane to obtain a cross-sectional view of the axillary artery. After visualization of the axillary artery and vein, the brachial plexus branches (lateral, median, posterior branch) around the artery were visualized and approached with a needle using in-plane technique. 15 mL of local anesthetic solution was mixed around the posterior cord and 7.5 mL each around the lateral and medial cords. Negative aspiration test was repeated every 5 mL. Ease of application was recorded as difficult (0), moderate (1), or easy (2) according to the ease of guiding the needle to the desired site during application, whether additional maneuvering or re-entry was required, and whether the clavicle interfered with needle guidance.

During the follow-up, the 0th minute was considered as the moment when the block was terminated, and the needle was removed from the skin. At 0. 5. 10. 15. 20. and 25 min, HR, TA, SpO2, StO2, PI, SpHb, rSO2 and body temperature data were recorded from both the blocked extremity and the other extremity. Bromage scale and Pinprick test using a 27-gauge blunt-tipped dental needle were checked 30 minutes after the block procedure and recorded.

Ethical approval

This study approval was obtained from the Harran University Faculty of Medicine. Ethics Committee (number: HRU/20.07.17; date: 13.04.2020). Informed consent was obtained from all patients. Our study was conducted according to the Declaration of Helsinki.

Statistical analysis

The conformity of the numerical data to normal distribution was tested by Shaphiro wilk test. Mann whitney u test was used to compare non-normally distributed variables between block successful and unsuccessful groups. In addition, Wilcoxon test was used to compare the non-normally distributed measurements between the block and control group, Freidman test was used to compare the measurements obtained at 7 different times over time and Dunn multiple comparison test was used to determine the significant times. The agreement between the methods was tested with Kappa statistics. Mean±standard deviation values, difference between means and 95% confidence intervals were used to summarize numerical variables, and number and % values were given for

categorical variables. SPSS windows version 24 was used in the analyses and a p value less than 0.05 was considered significant.

Results

A total of 91 patients who underwent hand. wrist and forearm operations between April 2019 and April 2019 were included in the study. Age. height. weight. BMI. gender. ASA physical scores. comorbidities and smoking status of the patients are given in **Table 1**.

Table 1. Demographic data. ASA risk group. comorbidities. smoking

Variables	Descriptive statistics (n=91)
Age (years)	36.31±13.08 (min=18-max=64)
Height (cm)	169.16±7.57
Weight (kg)	73.52±12.97
Body mass index (kg/m²)	25.71±4.44
Gender Female/ Male, (%)	39(42.9)/52(57.1)
ASA score I, (%)	40(44.0)
II, (%)	51(56.0)
Comorbidity Yes, (%)	21(23.1)
No, (%)	70(76.9)
Smoking Yes, (%)	27(29.7)
No, (%)	64(70.3)

A significant correlation was found between arm angle and USG visibility (P=0.001). Of those with poor USG visualization, 95.2% were in the 0° arm abduction group, all of those with fair USG visualization, were in the 45° arm abduction group and 97.1% of those with good USG visualization, were in the 90° arm abduction group **(Table 2)**.

Table 2. Ease of USG appearance according to different arm angles

	USG visibility		
	Bad	**Middle**	**Good**
Arm angle 0° abduction, (%)	20(95.2)	00(0.0)	1(2.9)
45° abduction, (%)	0(0.0)	35(100.0)	00(0.0)
90° abduction, (%)	1(4.8)	00(0.0)	34(97.1)

Of those who were easily applied, 51.2% were in the 90° arm abduction group **(Table 3)**.

Table 3. Ease of block application according to different arm angles

	Ease of implementation		
	Difficult	**Middle**	**Easy**
Arm angle 0° abduction,(%)	2(28.6)	15(36.6)	4(9.3)
45° abduction, (%)	2(28.6)	16(39.0)	17(39.5)
90° abduction, (%)	3(42.9)	10(24.4)	22(51.2)

No significant agreement was observed between the Bromage scale and pinprick test **(Table 4)**.

Table 4. Agreement between Bromage scale and Pin-prick test

		Bromage Scale			Total
		Motor power reduced but arm moving (0)	Arm is immobile but fingers are mobile(1)	Complete block. no movement in the hand and arm (2)	
Pinprick Test	No sensory block (0),(%)	6 (40)	0(0)	00(0)	6(6.6)
	There is a sense of touch. no pain (1),(%)	9(60)	18(48.6)	3(7.7)	30(33)
	No touch sensation and no pain (2),(%)	00(0)	19(51.4)	36(92.3)	55(60.4)
Total		15(100)	37(100)	39(100)	91(100)

The changes in temperature, StO2, rSO2, PI, SpHb in the measurements in the successful and unsuccessful groups are given in Table 5. StO2, rSO2 values at 5th min, PI value at 10th min and temperature (°C) values at 25th min block success significant difference was found in favor of the SpHb values, while a significant difference was found at any time in terms of SpHb values no difference was observed **(Table 5).**

Table 5. Changes in Temperature, StO_2, rSO_2, PI, SpHb Between Groups Over Time

Time	Variables	Successful (n=85)	Failed (n=6)	*p*
5. min	Temperature (°C)	36.06 ± 0.48	35.93 ± 0.69	0.671
	StO_2	84.95 ± 5.77	79.5 ± 4.42	0.020*
	rSO_2	75.92 ± 8.45	69.5 ± 2.95	0.018*
	PI	5.65 ± 2.41	3.54 ± 2.56	0.057
	SpHb	11.92 ± 1.09	12 ± 0.58	0.597
10. min	Temperature (°C)	36.26 ± 0.49	35.98 ± 0.74	0.400
	StO_2	86.33 ± 5.3	79.33 ± 6.31	0.012*
	rSO_2	77.27 ± 8.51	70.83 ± 3.66	0.023*
	PI	6.41 ± 2.4	4.32 ± 2.58	0.033*
	SpHb	11.95 ± 1.17	12.28 ± 0.58	0.294
15. min	Temperature (°C)	36.4 ± 0.45	35.98 ± 0.72	0.163
	StO_2	86.71 ± 5.42	79.83 ± 4.26	0.007*
	rSO_2	78.13 ± 8.68	71.5 ± 5.43	0.026*
	PI	6.34 ± 2.26	4.57 ± 2.5	0.038*
	SpHb	11.92 ± 1.15	12.25 ± 0.65	0.353
20. min	Temperature (°C)	36.5 ± 0.46	36.05 ± 0.71	0.112
	StO2	86.86 ± 4.92	81.17 ± 5.27	0.018*
	rSO2	78.87 ± 8.29	74.33 ± 9.14	0.078
	PI	6.12 ± 2.07	3.87 ± 1.39	0.009*
	SpHb	11.88 ± 1.18	12.33 ± 0.61	0.212
25. min	Temperature (°C)	36.59 ± 0.44	36.12 ± 0.65	0.050*
	StO_2	87.46 ± 4.7	81.5 ± 6.25	0.021*
	rSO_2	79.31 ± 8.73	73.33 ± 7.79	0.054
	PI	5.97 ± 1.97	3.38 ± 0.94	0.001*
	SpHb	11.86 ± 1.18	12.47 ± 0.57	0.096

Abbreviations: *Significant at 0.05 level. Mann whitney u test.

When block and control measurements were compared, StO2, rSO2, PI, SpHb values were found to be significantly higher in the block group compared to the non-block group at all times starting from the 0th minute **(Table 6).**

Table 6. Time dependent changes between the blocked group and the non-blocked group.

Variables	Block (n=91)	Unblocked extremity (n=91)	Median [min-max]	p
Temperature (°C) Before	35.84 ± 0.49	35.76 ± 0.5	0.08 [0.02 -0.13]	0.012*
Temperature (°C) 0. min	35.89 ± 0.48	35.76 ± 0.46	0.13 [0.07 -0.2]	0.001*
Temperature (°C) 5.min	36.05 ± 0.49	35.75 ± 0.49	0.3 [0.23 -0.38]	0.001*
Temperature (°C) 10.min	36.24 ± 0.51	35.71 ± 0.49	0.54 [0.46 -0.61]	0.001*
Temperature (°C) 15.min	36.38 ± 0.48	35.68 ± 0.48	0.7 [0.61 -0.78]	0.001*
Temperature (°C) 20.min	36.47 ± 0.49	35.67 ± 0.47	0.8 [0.71 -0.88]	0.001*
Temperature (°C)25.min	36.56 ± 0.47	35.66 ± 0.47	0.9 [0.8 -0.99]	0.001*
StO2 Before	80.55 ± 5.87	80.21 ± 5.74	0.34 [0.58 -1.26]	0.658
StO2 0.min	81.8 ± 5.99	79.19 ± 5.91	2.62 [1.57 -3.66]	0.001*
StO2 5.min	84.59 ± 5.83	78.53 ± 5.98	6.07 [4.98 -7.15]	0.001*
StO2 10.min	85.87 ± 5.61	78.48 ± 6.21	7.38 [6.25 -8.52]	0.001*
StO2 15.min	86.25 ± 5.6	78.27 ± 6.26	7.98 [6.7 -9.26]	0.001*
StO2 20.min	86.48 ± 5.11	78.04 ± 6.6	8.44 [7.13 -9.75]	0.001*
StO2 25.min	87.07 ± 5	77.73 ± 6.55	9.34 [8.07 -10.62]	0.001*
rSO2 Before	70.6 ± 8.07	68.67 ± 7	1.93 [0.57 -3.29]	0.003*
rSO2 0	71.74 ± 8.59	68.58 ± 7.09	3.15 [1.5 -4.81]	0.001*
rSO2 5	75.49 ± 8.35	67.18 ± 7.57	8.32 [6.42 -10.21]	0.001*
rSO2 10	76.85 ± 8.42	66.98 ± 7.29	9.87 [7.93 -11.8]	0.001*
rSO2 15	77.69 ± 8.64	67.08 ± 7.57	10.62 [8.66 -12.57]	0.001*
rSO2 20	78.57 ± 8.37	66.59 ± 7.73	11.98 [9.93 -14.02]	0.001*
rSO2 25	78.91 ± 8.76	66.64 ± 7.78	12.27 [10.23 -14.31]	0.001*
PI Before	3.17 ± 1.94	3.24 ± 2.1	-0.07 [-0.45 -0.32]	0.799
PI 0.min	3.85 ± 2.31	3.07 ± 2.14	0.78 [0.3 -1.26]	0.001*
P 5.min	5.51 ± 2.46	2.85 ± 2.16	2.66 [2.16 -3.16]	0.001*
P 10.min	6.27 ± 2.45	3.01 ± 2.3	3.27 [2.66 -3.88]	0.001*
P 15.min	6.22 ± 2.3	2.82 ± 2.08	3.41 [2.86 -3.95]	0.001*
P 20.min	5.97 ± 2.11	2.52 ± 1.86	3.46 [2.97 -3.95]	0.001*
PI 25.min	5.8 ± 2.02	2.42 ± 1.66	3.38 [2.93 -3.83]	0.001*

Abbreviations: *Significant at 0.05 level. Mann whitney u test.

Discussion

In our study evaluating tissue oxygenation and block quality using NIRS in USG-guided infraclavicular block application at different arm angles in upper extremity surgeries, we found that 90° abduction of the arm while the forearm was in the anatomical position increased USG visibility and provided better ease of application, and StO2, rSO2, PI value and body temperature measurements gave significant results in evaluating block success.

During ultrasound-guided infraclavicular block application, different angles can be given to the arm and forearm to increase visibility, facilitate needle manipulation and apply the block faster. Studies have shown that 90° abduction of the arm improves image quality, decreases the distance of the brachial plexus to the skin, facilitates needle guidance, and reduces the risk of pneumothorax and arterial puncture (5,6). We evaluated the visibility on USG by giving the arm an abduction angle of 0 degrees, 45 degrees and 90 degrees respectively while the forearm was in the anatomical position on the side to be blocked. We found that the 90° abduction group had better and significant USG visibility (P=0.001).

In their study, Auyong et al. reported that the brachial plexus became more superficial with 90 degrees of arm abduction, at the same time the clavicle was displaced cranioposteriorly and thus needle manipulation was easier (19). In our study, similar to the study of Auyong et al. we observed that the ease of application of the block

increased as the arm abduction angle increased.

In our study, we investigated whether we could objectively evaluate the success of infraclavicular block using rSO2 and StO2 values obtained by NIRS. NIRS is a non-invasive and relatively low-cost technique that provides information about the oxygenation of a biological tissue such as muscle tissue. Its use as cerebral regional oxygen saturation measured by NIRS has been approved by the FDA (20).

There are a limited number of studies in the literature on the use of NIRS in regional anesthesia. For the first time, Tsai et al. found a statistically significant increase of approximately 15% in regional oxygen saturation in the blocked extremity before the patients perceived sensory and motor loss starting from the 5th minute (21). They stated that these changes may be due to a sympathectomy-like effect of brachial plexus block, increased diastolic flow and decreased peripheral resistance based on the study of Shemesh et al. (22).

Tighe et al. found a significant increase in rSO2 only in the extremity in which infraclavicular block was applied in their patients in whom they performed cervical paravertebral nerve block, femoral nerve block, infraclavicular nerve block and sciatic nerve block, and they could not detect a significant difference between rSO2 values in other blocks (23).

In the study by Karahan et al. aiming to investigate whether tissue oxygen saturation (StO2) is a reliable and objective method to evaluate the adequacy of infraclavicular block, they applied infraclavicular block in patients undergoing hand surgery and it was reported that it was useful in demonstrating block success and practically noninvasively demonstrated a successful block even in the first 5 minutes (24).

In our study, we found a significant difference in StO2 in both extremities and between the successful and unsuccessful groups of the block. Similar to the study of Tsai et al., in our study, we observed statistically significant increases in tissue oxygen saturation in the blocked extremity from the 5th minute after the block, although there was no difference between basal values and 0.min after the block. In the rSO2 value, we observed a significant difference between the blocked group and the unblocked group at all times. In the blocked group, we observed statistically significant increases in the regional oxygen saturation in the blocked extremity from the 5th minute after the block, while there was no difference between the baseline values and the 0th minute after the block, as in StO2. This significant difference continued between 0 and 5 minutes and other time periods in both StO2 and rSO2, while no significant difference was observed at 10 minutes and later. We attribute this to the fact that there was no statistically significant difference between the 10th minute and the other times since the block level started to settle after the 10th minute and the effect of the block exceeded a certain level.

The perfusion index (PI) represents the ratio of pulsatile to nonpulsatile blood flow in peripheral tissue and represents a continuous, noninvasive measurement of peripheral perfusion obtained from a pulse oximeter. In patients undergoing regional anesthesia, sympathetic block occurs before sensory and motor block develop due to the block, and perfusion increases in the area of sympathetic block due to local vasodilation. As a result, an increase in PI occurs due to an increase in pulsatile blood flow (11,13,25). PI value showed a significant increase from 5 minutes in the studies of Lee JY et al. and from 10 minutes in other studies. In conclusion, it has been concluded that perfusion index (PI) measurement is very valuable and usable in early, easy and objective evaluation of the success of peripheral nerve blocks (26). In our study, an increase of 2.04 was observed between the PI value before anesthesia in the block successful group and the block successful group after the 10th minute.

Bergek et al. investigated the effects of brachial plexus block on SpHb, PVI and PI parameters. In their study, basal values before the block and values up to the 20th minute after the block were recorded. There was no significant change in PI, PVI, SpHb or invasive Hb in the unblocked arm. They stated that these changes in values may be related to dilatation of vascular structures due to blockade (17). In our study, no significant difference was observed in the SpHb value both between the block group and the non-block group and within the groups.

Recently, there have been a number of studies investigating whether an increase in skin temperature in the innervated area precedes sensory block. In the literature, it has been reported that measurement of skin temperature is a reliable and feasible diagnostic tool to evaluate the success or failure of regional anesthesia procedures, especially in patients in whom sensory tests such as pinprick and cold sensation tests cannot be performed, but it occurs later than the loss of sensory and motor functions (27).

When we looked at the comparison of temperature values between and within groups in our study, we observed a significant difference between the block group and the non-block group at all times period from the pre-block measurement. When we evaluated the block group within itself between times, there was a significant difference in the direction of increase in temperature. When we looked at the difference between the block successful and block

unsuccessful groups, a significant increase was detected in the block successful group after 25 minutes. Contrary to the findings in the literature, temperature gave significantly higher results later in our study.

Study limitations

The study is a measurement study performed with an ultrasound device during clinical practice. The measurements performed with ultrasound may vary depending on the characteristics of the ultrasound, the ultrasound probe, and the weight of the person undergoing the ultrasound. Another limitation of the study is that the measurement may vary depending on whether the person applying the ultrasound presses the probe on the skin.

Conclusion

In conclusion, we believe that during infraclavicular block application, 90° abduction of the arm while the forearm is in the anatomical position increases USG visibility and provides better ease of application, and StO2, rSO2, PI and body temperature measurements will be useful to evaluate block success.

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Ethical Approval: *This study approval was obtained from the Harran University Faculty of Medicine. Clinical Research Ethics Committee (number: HRU/20.07.17, date: 13.04.2020). Informed consent was obtained from all patients.*

Author Contributions: *Concept: BO, CSA. Literature Review: KMA, PB. Design: PVF, DE, SA Data acquisition: CSA, KMA. Analysis and interpretation: PB, SA. Writing manuscript: OB, PB. CSA Critical revision of manuscript: OB, PV.*

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References

1. Danial Shams, Kaylyn Sachse, Nicholas Statzer, et al. Regional Anesthesia Complications and Contraindications Clin Sports Med. 2022;41(2):329-43.
2. Peter E Amato, Andrew J Winkelman, Grace L Forster, et al. Regional Anesthesia for Hip Arthroscopy Clin Sports Med. 2022;41(2):233-46.
3. Koscielniak-Nielsen ZJ, Rasmussen H, Hesselbjerg L, et al. Infraclavicular block causes less discomfort than axillary block in ambulatory patients. Acta Anaesthesiol Scand. 2005; 49: 1030-4.
4. Framarz Mosaffa, Babak Gharaei, Mehran Rafeeyan, et al. Comparing vertical and coracoid approaches for infraclavicular block in orthopedic surgery of the forearm and hand J Clin Anesth. 2012;24(3):196-200.
5. Ruíz A, Sala X, Bargalló X, et al. The influence of arm abduction on the anatomic relations of infraclavicular brachial plexus: an ultrasound study. Anesth Analg. 2009; 108:36-6.
6. Wang FY, Wu SH, Lu IC, et al. Ultrasonographic examination to search out the optimal upper arm position for coracoid approach to infraclavicular brachial plexus block--a volunteer study. Acta Anaesthesiol. 2007; 45:15-20.
7. Daniela Messineo, Paolo Izzo, Pier Francesco Di Cello, et al. Sensory block in Day Surgery Ann Ital Chir. 2020:91:310-3.
8. Sertan Acar, Yavuz Gürkan, Mine Solak, et al. Coracoid versus lateral sagittal infraclavicular block Acta Orthop Traumatol Turc. 2013;47(1):32-7.
9. Araz C, Gürkan Y, Kuş A, Artificial-coloring in ultrasound-guided regional anesthesia. Agri. 2023;35(1):10-5.
10. Josef Zekry Attia, Rowaida Nabil Gaber, Shadwa Rabea Mohamed, Ultrasound-guided Retroclavicular Approach Versus Costoclavicular Approach of Infraclavicular Brachial Plexus Block for Upper Limb Surgeries Pain Physician. 2023;26(6): E651-60.
11. Alparslan Kus, Yavuz Gurkan, Suna Kara Gormus, et al. Usefulness of perfusion index to detect the effect of brachial plexus block J Clin Monit Comput. 2013;27(3):325-8.
12. Eilish M Galvin, Sjoerd Niehof, Serge Jc Verbrugge, et al. Peripheral flow index is a reliable and early indicator of regional block success Anesth Analg. 2006;103(1):239-43.
13. Abdelnasser, B Abdelhamid, A Elsonbaty, et al. Predicting successful supraclavicular brachial plexus block using pulse oximeter perfusion index Br JAnaesth. 2017;119(2):276-80.
14. Binici O, Karahan MA, Buyukfirat E. Evaluation of tissue oxygenation and block quality using Near Infrared Spectroscopy (NIRS) in patients undergoing ultrasound-guided infraclavicular block at different arm angles A prospective observational study. Ann Ital Chir. 2019:90:357-63.
15. Krzysztof B Beć, Justyna Grabska, Christian W Huck. Near-Infrared Spectroscopy in Bioapplications molecules. 2020;25(12):2948.

16. Hong Wei, Han-Kun Tu, Shang-Long Yao, et al. Regional tissue oxygen saturation as a predictor of post-spinal anesthesia hypotension for cesarean delivery Chin Med J (Engl). 2021;134(19):2353-5.
17. C Bergek, J H Zdolsek, R G Hahn. Non-invasive blood haemoglobin and plethysmographic variability index during brachial plexus block Br J Anaesth. 2015;114(5):812-7.
18. Vincent Minville, Agnés Gendre, Jan Hirsch, et al. The efficacy of skin temperature for block assessment after infraclavicular brachial plexus block Anesth Analg. 2009;108(3):1034-6.
19. David B Auyong, Jeff Gonzales, James G Benonis. The Houdini clavicle: arm abduction and needle insertion site adjustment improve needle visibility for the infraclavicular nerve block Reg Anesth Pain Med. 2010;35(4):403-4.
20. Hernandez-Meza G, Izzetoglu M, Osbakken M, et al. Near-infrared spectroscopy for the evaluation of anesthetic depth. Biomed Res Int. 2015; 2015:939418.
21. Phil B Tsai, Vadim Tokhner, Jichang Li, et al. A new application for near-infrared spectroscopy in regional anesthesia? J Anesth. 2011;25(1):140-1.
22. Shemesh D, Olsha O, Orkin D, et al. Sympathectomy-like effects of brachial plexus block in arteriovenous access surgery. Ultrasound Med Biol. 2006;32(6):817-22.
23. P J Tighe, C E Elliott, S D Lucas, et al. Noninvasive tissue oxygen saturation determined by near-infrared spectroscopy following peripheral nerve block Acta Anaesthesiol Scand. 2011;55(10):1239-46.
24. Karahan MA, Binici O, Büyükfırat E. Tissue Oxygen Saturation Change on Upper Extremities After Ultrasound-Guided Infraclavicular Brachial Plexus Blockade; Prospective Observational Study Medicina (Kaunas). 2019;55(6):274
25. Zifeng Xu, Jianhai Zhang, Hao Shen, et al. Assessment of pulse oximeter perfusion index in pediatric caudal block under basal ketamine anesthesia. Scientific World Journal. 2013:183493.
26. Jin Young Lee, Eung Don Kim, Yoo Na Kim, et al. Correlation of Perfusion Index Change and Analgesic Efficacy in Transforaminal Block for Lumbosacral Radicular Pain. J Clin Med. 2019;8(1):51.
27. H Hermanns, R Werdehausen, M W Hollmann, et al. Stevens Assessment of skin temperature during regional anesthesia What the anesthesiologist should know. Acta Anaesthesiol Scand. 2018;62(9):1280-9

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Diagnostic Values of Blood and Serum Markers for Active Disease in Children with Ulcerative Colitis

Ülseratif Kolitli Çocuklarda Kanve Serum Belirteçlerinin Aktif Hastalık İçin Tanısal Değerleri

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Abstract

Background: Ulcerative colitis is a chronic inflammatory bowel disease characterized by colonic mucosal ulceration. The search for noninvasive tests can reduce the use of endoscopy in the diagnosis and treatment monitoring of ulcerative colitis is ongoing. This study aimed to find noninvasive biomarkers for endoscopically diagnosed ulcerative colitis that adequately reflect histologic disease activity.

Materials and Methods: This study is based on the retrospective comparison of the data of pediatric patients between the ages of 0-18 years who were followed up with a diagnosis of ulcerative colitis and healthy children who were constituted the control group. Pre- and post-treatment values of these parameters in the patient group and control group parameters were compared separately.

Results: The present study was conducted with a total of 72 children, including 36 ulcerative colitis and 36 healthy controls. Following a comparative analysis of four parameters (ESR, CRP, MCV, and albumin) were identified as exhibiting similar characteristics across the high and low levels. The logistic regression analysis of these parameters revealed that ESR and CRP were associated with a high ulcerative colitis diagnosis, while MCV and albumin were associated with a low diagnosis. In the ROC analysis, whereas 8.5 mm/h for ESR and 1.89 mg/L for CRP were found as cut-off values.

Conclusions: In cases where there is suspicion of inflammatory bowel disease, it would be appropriate to refer patients to procedures involving simple blood tests. This approach is preferable to reaching a diagnosis with costly, difficult-to-access noninvasive tests or invasive procedures. The presence of ESR and CRP elevation, as well as low levels of MCV and albumin, can serve as a triage tool.

Keywords: Biomarker, cut-off value, inflammatory bowel disease, noninvasive test, ulcerative colitis.

ÖZ

Amaç: Ülseratif kolit, kolonik mukozal ülserasyon ile karakterize kronik bir inflamatuvar bağırsak hastalığıdır. Ülseratif kolit tanı ve tedavi izleminde endoskopi kullanımını azaltabilecek testlerin arayışı devam etmektedir. Bu çalışmanın amacı, endoskopi yoluyla teşhis edilen ülseratif kolit için, histolojik hastalık aktivitesini yeterince yansıtan noninvazif biyobelirteçler bulmaktır.

Gereç ve Yöntem: Bu çalışma ülseratif kolit tanısı alarak izlenen, 0-18 yaş arasındaki çocuk hastalar ile; sağlıklı olarak izlenen çocukların kontrol grubunu oluşturup retrospektif olarak verilerinin karşılaştırılması esasına dayanır. Bu parametrelerden kontrol grubu ile hasta grubunun tedavi öncesi ve sonrası değerleri ayrı ayrı karşılaştırıldı.

Bulgular: Çalışma 36 ülseratif kolit hastası ve 36 sağlıklı olmak üzere 72 çocuk ile gerçekleştirilmiştir. Sonuçlarımızda yüksekliği ve düşüklüğü ile benzer özellikte, anlamlı ortak dört parametre bulundu (ESR, CRP, MCV ve albümin). Bu parametrelerin lojistik regresyon analizinde ESR ve CRP yüksekliği ile; MCV ve albümin ise düşüklüğü ile ülseratif kolit tanısında ayrı ayrı bağımsız birer risk olduğu saptandı. ROC analizinde ESR için 8.5 mm/h ve CRP için 1.89 mg/L sınır değerler olarak bulundu.

Sonuç: Çalışma sonuçlarımıza göre inflamatuvar bağırsak hastalığı şüphesi varlığında yüksek maliyetli, zor ulaşılabilen noninvazif testlerle ya da invazif işlemlerle tanıya ulaşmak yerine, kolay, ucuz ve ulaşılabilir olan basit kan testleriyle hastayı bu işlemlere yönlendirmenin uygun olacağı; ESR ile CRP yüksekliği ve MCV ile albümin düşüklüğünün tamamı ya da birinin varlığını bir triyaj aracı olarak kullanıp hastayı histolojik tanıya yönlendirmenin uygun olacağı kanaatindeyiz.

Anahtar kelimeler: Biyobelirteç, inflamatuvar bağırsak hastalığı, noninvaziv test, sınır değer, ülseratif kolit.

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Highlights

- Pediatric patients with ulcerative colitis and healthy children were analyzed comparatively.
- Biomarkers that may reflect the histologic diagnosis of ulcerative colitis were investigated.
- Cut-off value research was conducted for the biomarkers found.

Introduction

Ulcerative colitis (UC) is a chronic inflammatory bowel disease (IBD) characterized by colonic mucosal ulceration and bloody diarrhea during relapses. The prevalence of IBD is increasing in both adult and pediatric populations, and this increase parallels industrialization (1). The etiology of IBD appears to be associated with changes in the environment and diet that can lead to alterations in the microbiota, which, in genetically susceptible individuals, result in the development of IBD (2). The symptoms associated with UC are typically mild and clinically difficult to distinguish from functional disorders such as irritable bowel syndrome (IBS), in which diarrhea predominates. The manifestation of both conditions may include altered bowel habits and abdominal pain. The absence of specific biomarkers further complicates diagnosis, as it often leads to prolonged diagnostic delays (3). Early diagnosis is therefore paramount in UC patients, as it can prevent long-term complications, including delayed puberty, nutritional and growth retardation, inadequate response to treatment, and the need for surgery.

The diagnosis of ulcerative colitis is determined through a series of evaluations, including invasive procedures such as colonoscopy. There is no gold standard diagnosis for UC. In recent years, there has been an ongoing search for noninvasive tests, such as blood-stool markers and ultrasonography, which could reduce the use of endoscopy in UC diagnosis and treatment monitoring. The rationale behind this is twofold: first, the procedure is invasive, and second, it is performed under general anesthesia. Consequently, the development of noninvasive tests for UC can assist clinicians in addressing this diagnostic challenge. These tests can function as a triage tool, safely ruling out existing UC and directing patients for further investigations (4).Currently, fecal calprotectin (FCal) and C-reactive protein (CRP) are most widely used biomarkers; however, they lack specificity for UC because they are present in high concentrations in a wide range of inflammatory diseases of the lower gastrointestinal tract (5-7). FCal plays a crucial role in differentiating between IBD and IBS but CRP can't do that either. Circulating microRNAs and exosomes have shown promise in monitoring disease activity and predicting exacerbations without requiring invasive procedures. Receptor inhibitors such as Janus kinases, interleukin 23 and Smad7, and fatty acid modulators are under investigation and have the potential for clinical efficacy. But the use of none of them is widespread and clear (8).

The utilization of specific laboratory parameters has the potential to facilitate the diagnosis of CUC, particularly in cases where children present with symptoms of severe disease, such as rectal bleeding, weight loss, abdominal tenderness, or milder symptoms, including occasional abdominal discomfort and intermittent episodes of loose stools. However, a comprehensive evaluation of the diagnostic accuracy of the disease when combining all symptoms and noninvasive tests other than FFCal is currently unavailable. Furthermore, the optimal combination of tests or the superiority or cut-off value of a single test over other tests has rarely or never been examined. Consequently, the objective of this study was to identify cost-effective, readily accessible, noninvasive biomarkers for UC diagnosed by endoscopy in children presenting with diverse gastrointestinal symptoms that accurately reflect histologic disease activity. The objective of this study was twofold: first, to determine the association of UC with the single or combined use of these biomarkers, and second, to provide cut-off values for disease prediction with these biomarkers.

Material and Methods

Study design

The present study was based on a comparison of pediatric patients between 0-18 years of age who were followed up with a diagnosis of Ulcerative Colitis (UC) in the Department of Pediatric Gastroenterology of Selçuk University Faculty of Medicine with healthy children who were followed up in the same period by the Department of Pediatric Infectious Diseases as the control group. The control group comprised children between the ages of 0-18 years, whose treatment was completed due to upper respiratory tract infection, who had the necessary data for the study after treatment, and who were determined after simple random selection in order to ensure numerical homogenization between the groups. The data of both groups was retrospectively recorded and

analyzed in the hospital automation system.

The patient group consisted of 36 patients with newly diagnosed UC between September 2012 and July 2020. The diagnosis was made in accordance with the European Society of Pediatric Gastroenterology, Hepatology, and Nutrition guidelines, incorporating both endoscopic and histological criteria. Patients with Crohn's disease and indeterminate colitis were excluded from the study. Disease activity was calculated according to the Pediatric Ulcerative Colitis Index (PUCAI) and graded as remission (<10 points), mild or inactive (<35 points), moderate (35-64 points), or severe (>64 points) (9). Patients were not receiving treatment at the time of diagnosis and sampling for tests. The control group consisted of 36 healthy children with excluded gastrointestinal inflammatory disease.

The demographic and clinical characteristics of the study participants, including their age, gender, and PUCAI scores, were documented. Additionally, the following laboratory parameters were recorded: Erythrocyte sedimentation rate (ESR), CRP, mean corpuscular volume (MCV), hemoglobin (Hb), leukocyte (WBC), and platelet counts from venous blood, as well as mean corpuscular volume (MCV), hemoglobin (Hb), leukocyte (WBC), and platelet counts from complete blood count components. Neutrophil, lymphocyte, eosinophil, basophil, monocyte counts and ratios, red blood cell distribution width (RDW), RDW to platelet ratio (RPR), and albumin values were recorded.

Statistical analysis

The data obtained in the study were subjected to descriptive statistics, which included the calculation of the mean and standard deviation. The distribution of the data was then examined to determine its conformity to the normal distribution using the Kolmogorov-Smirnov test. The results indicated that the data did not conform to a normal distribution ($p < 0.05$). Following this observation, the Mann-Whitney U test and Wilcox test were employed to conduct a comparative analysis between the patient and control groups. The chi-square test was employed to compare categorical data. For the study, $p<0.05$ was considered statistically significant. All statistical analyses were conducted using the SPSS 25.0 program (SPSS Inc., Chicago, IL, USA).

Ethical Approval

This study approval was obtained from the Selçuk University Faculty of Medicine, Ethics Committee (number: 2020/318. date: 27.07.2020). The data of both groups was retrospectively recorded and analyzed in the hospital automation system. This study was conducted retrospectively. Therefore, no consent form was obtained. All procedures were carried out in accordance with the Declaration of Helsinki.

Results

The present study was conducted with a total of 72 children, including 36 patients with UC who met the exclusion criteria and 36 participants who served as the control group. The mean age of the study population was 13.16 years (range 4/16 years for the control group and 7/17 years for the patient group) and included 28 boys (15 patients/13 controls) and 44 girls (21 patients/23 controls). The study's findings were derived from a comparative analysis of the medical records of the control group with the patient group's data at the time of diagnosis and the patient group's post-treatment data. The statistical analysis revealed that factors such as age (p=0.001), PUCAI (p=0.001), ESR (p=0.001), CRP (p=0.001), WBC count (p=0.007), neutrophil count (p=0.001), and percentage (p=0.001), platelet count (p=0.001), monocyte count (p=0.001), RDW (p=0.001), neutrophil/lymphocyte ratio (NLR) (p=0.001) and platelet/lymphocyte ratio (PLR) (p=0.001) were significantly higher in the patient group, while MCV (p=0.001), Hb (p=0.001), lymphocyte count (p=0.008) and ratio (p=0.001), lymphocyte/monocyte ratio (LMR) (p=0.001) and albumin value (p=0.001) were significantly lower in the patient group compared to the control group (Table 1).

A comparative analysis of the post-treatment data from the patient group and the control group revealed that the levels of CRP (p=0.026), neutrophil count (p=0.012), and percentage (p=0.001), platelet count (p=0.041), monocyte count (p=0.001), RDW (p=0.001), and NLR (p=0.001). Conversely, the patient group exhibited significantly elevated CRP (p=0.026), neutrophil count (p=0.012), percentage (p=0.001), platelet count (p=0.041), monocyte count (p=0.001), RDW (p=0.001), NLR (p=0.001), and PLR (p=0.001) ratios, while Hb (p=0.001), lymphocyte count (p=0.006), and ratio (p=0.001), LMR ratio (p=0.001), and albumin value (p=0.001) were significantly lower in the patient group after treatment **(Table 1)**.

A comparative analysis of the patient group's data at the time of diagnosis and the post-treatment data set revealed that ESR (p=0.001), CRP (p=0.001), and eosinophil percentage (p=0.046) exhibited significant increases, while MCV

(p=0.039) and albumin value (p=0.001) demonstrated significant decreases **(Table 1)**.
After the comparison of three different data sets, four parameters (ESR, CRP, MCV, and albumin) were found to be statistically significant with similar characteristics of high and low levels. Logistic regression analysis of these parameters revealed that ESR (Odds 1.148 and p=0.023) and CRP (Odds 1.632 and p=0.041) were significantly independent risk factors for UC diagnosis with high levels, while MCV (Odds 0.891 and p=0.018) and albumin (Odds 0.022 and p=0.001) were significantly independent risk factors for UC diagnosis with low levels **(Table 2)**. According to ROC analysis; ESR>8.5 mm/h cut-off value with 72.2% sensitivity and 27.8% specificity (p= 0.001; AUC 0.807); CRP>1.89 mg/L cut-off value with 69.4% sensitivity and 30.6% specificity (p= 0.001; AUC 0.764) support the diagnosis of UC. According to these results, no cut-off value could be determined for albumin and MCV because AUC<0.5 **(Table 2, Figure 1)**.

Table 1. Comparison of the values of the patient group pre-post treatment and the control group.

Variables	A	B	C	*A / B p*	*A / C p*	*B / C p*
Age, (years)	10.64 ± 3.97	14.28 ± 2.75	14.58 ± 2.78	0.001	0.001	0.002
Gender, (%) (Boy/Girl)	13 (36.1) / 23 (63.9)	15 (41.7) / 21 (58.3)	15 (41.7) / 21 58.3)	0.765		
PUCAI Score				0.001		
Remission (<10)	36(100)		35(97.2)			
Mild activity (10 – 34)		5(13.9)	1(2.8)			
Moderate activity (35 – 64)		22(61.1)				
Severe activity (65 – 85)		9(25)				
ESR	6.67 ± 5.11 (2-17)	28.25 ± 27.8 (2-111)	9.28 ± 8.28 (2-44)	0.001	0.134	0.001
CRP	1.67 ± 1.32 (0.60-5.99)	28.87 ± 47.67 (0.20-165)	2.72 ± 3.64 (0.11-23)	0.001	0.026	0.001
MCV	82.54±6.27 (58-92.2)	74.95 ± 8.50 (60-92)	80.13±10.45 (62-108)	0.001	0.111	0.039
Hb	13.4±1.18 (10.7-16)	10.95 ± 2.52 (5.8-14.8)	11.8±2.05 (7.5-14.9)	0.001	0.001	0.232
WBC	7.07 ± 2.06 (2.8-12.2)	9.72 ± 5.29 (1.90-31)	8.08±4.0 (1.6-24.4)	0.007	0.322	0.093
Neutrophile (%)	51.53 ± 10.24 (30.2-71)	64.02 ± 11.16 (44-84)	62.38-13.37 (30-85.1)	0.001	0.001	0.857
Lymphocyte (%)	37.74 ± 9.61 (21-57.7)	23.73 ± 9.05 (6.30-43)	27.46 ± 11.69 (9.8-59)	0.001	0.001	0.238
Eosinophils (%)	2.43 ± 2.36 (0.30-10.90)	3.04-2.98 (0-12.30)	1.81-1.61 (0-6.79)	0.562	0.169	0.046
Basophile (%)	0.38±0.27 (0-1.10)	0.43±0.34 (0-2.10)	0.54±0.72 (0.10-4.5)	0.444	0.257	0.312
Monocyte (%)	7.52 ± 1.66 (4-11.8)	8.06 ± 3.21 (0.90-15.9)	7.45 ± 2.44 (4.06-16.0)	0.608	0.414	0.338
Platelet ($\times10^{-3}$)	305.67 ± 66.17 (176-453)	396.58 ± 120.35 (113-709)	364.03 ± 110.361 (189-625)	0.001	0.041	0.056
Neutrophile count	3.75 ± 1.56 (0.90-8)	6.78±4.55 (2.20-25)	5.34 ± 3.51 (1.60-20.8)	0.001	0.012	0.144
Lymphocyte count	2.61 ± 0.89 (1.10-4.80)	2.11±0.74 (0.70-4.0)	2.10 ± 1.04 (0.98-6.47)	0.008	0.006	0.184
Monocyte count	391.39 ± 258.52 (50-1000)	781.6 ± 563.99 (88-2600)	745.56 ± 951.12 (200-6100)	0.001	0.001	0.160
Eosinophils count	132.5 ± 173.44 (0-700)	209±271.13 (0-1310)	176.94 ± 338.8 (0-2000)	0.225	0.544	0.112
Basophile count	202.78 ± 277.16 (0-990)	30.42 ± 43.10 (0-200)	35.03 ± 67.86 (0-400)	0.092	0.213	0.939
RDW	13.51 ± 1.09 (11.9-17.2)	16.55 ± 4.45 (12.6-32)	16.74 ± 3.62 (12.2-25.6)	0.001	0.001	0.604
NLR	1.57 ± 0.73 (0.56-3.32)	3.72 ± 3.09 (1.06-14.14)	2.93 ± 1.88 (0.51-8.67)	0.001	0.001	0.481
LMR	12.15 ± 12.33 (2.7-47)	4.41 ± 5.17 (0.59-28.07)	3.7 ± 1.87 (0.49-8.94)	0.001	0.001	0.540
PLR	129.41 ± 55.03 (53.48-329.09)	219.77 ±128.21 (59.47-665.71)	200.43 ± 82.95 (67.08-373.15)	0.001	0.001	0.925
Albumin	4.24 ± 0.43 (3.5-5.20)	3.22 ± 0.77 (1.5-4.6)	3.92 ± 0.43 (3.10-4.60)	0.001	0.010	0.001
RPR ($\times10^{6}$)	6.67 ± 5.12 (2-17)	28.25 ± 27.29 (2-111)	9.28 ± 8.28 (2-44)	0.253	0.648	0.090

Abbreviations: **A**-Control group mean±sd (min-max); **B**-Patient pretreatment mean±sd (min-max); **C**-Patient posttreatment mean±sd, (min-max); CRP:C-Reaktive Protein; ESR: Erythrocyte Sedimentation Rate; Hb:Haemoglobin; LMR:Lymphocyte Monocyte Ratio; MCV:Mean Corpuscular Volume; NLR:Neutrophile Lymphocyte Ratio; PUCAI: Pediatric Ulcerative Colitis Activity Index; RDW:Red Cell Distribution Width; PLR: Platelet Lymphocyte Ratio; RPR: RDW Platelet Ratio; WBC: White Blood Cell)

Table 2. LRA and ROC analysis of four common parameters.

	LRA		ROC			
	Odds ratio	**p**	**Area**	**p**	**Sensitivity**	**Specificity**
ESR	1.148	0.023	0.807	0.001	0.722	0.278
CRP	1.632	0.041	0.764	0.001	0.694	0.306
MCV	0.891	0.018	0.230	0.001	-	-
Albumin	0.022	0.001	0.105	0.001	-	-

Abbreviations: CRP:C-Reactive Protein; ESR: Erythrocyte Sedimentation Rate; LRA: Logistic regression analysis; MCV: Mean Corpuscular Volume; ROC: Receiver Operating Characteristic)

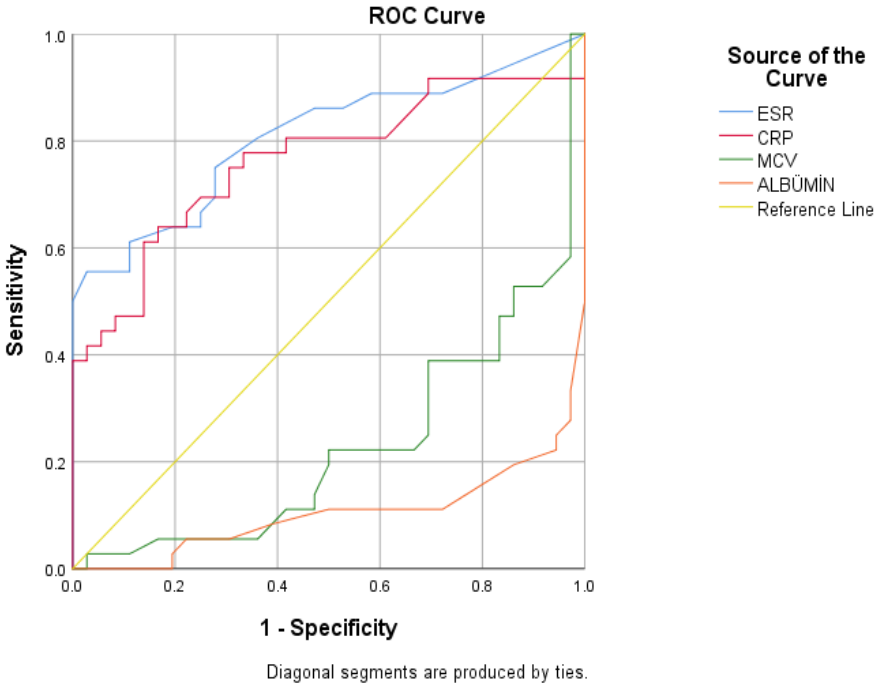

Figure 1. ROC curve analysis of four common parameters

Discussion

Mucosal healing is associated with long-term clinical remission following treatment and has been shown to improve long-term prognosis by reducing the risk of hospitalization and surgical intervention (10). Mucosal healing is identified through endoscopic procedures; however, colonoscopy is a highly invasive examination, and frequent examinations are challenging due to their significant medical cost. Consequently, there is a clinical need for noninvasive, cost-effective diagnostic tools for mucosal healing using biomarkers that are useful in the diagnosis, treatment, and monitoring of UC. This is particularly salient in the pediatric population, where hospitalization is often necessary to ensure adequate bowel cleansing for endoscopies and biopsies and to provide sedation or anesthesia of sufficient quality in a child-friendly environment. It is imperative to acknowledge that these procedures are not only associated with significant risks and complications for the patient but also result in the utilization of valuable healthcare system resources (11,12). Therefore, there is a need for noninvasive measurement tools to minimize the invasiveness, discomfort, potential complications, and cost associated with these procedures.

One approach is to look at the patient's FCal serum amyloid A (SAA) parameters, but due to the lack of comprehensive analysis, availability, and high cost, a decrease in ESR and CRP or an increase in albumin and MCV from our study results can be used as a marker of mucosal healing.

Weinstein et al. analyzed the laboratory test results of 71 children with newly diagnosed UC. The researchers reported that the absolute laboratory values for ESR and platelet count were higher, whereas the absolute values for hemoglobin and albumin levels were lower at the time of presentation. The researchers also identified a substantial overlap in laboratory values among children with mild to moderate disease (13). Conversely, our results demonstrate that ESR and platelet counts were significantly higher, while hemoglobin and albumin levels were significantly lower in children with UC at the time of diagnosis compared to the control group. However, the study did not incorporate a grading system based on disease severity.

The pathogenesis of ulcerative colitis involves complex dysregulation of mucosal immune cells (14) and concomitant invasion by neutrophils, leading to the formation of crypt abscesses and dysfunction of the colonic epithelial barrier (15). Neutrophils reach the colonic lumen during transmigration and can be detected in the stool (16), similar to the mediators they secrete (17,18), such as polymorphonuclear elastase, Cal or Cathepsin G. Therefore, biomarkers reflecting neutrophil activation seem promising in UC (18,19). It can be expected that the concentration of inflammatory cells in the blood will increase during neutrophil activation that occurs in active inflammatory processes of UC. The proven importance of platelet count as a biomarker in UC, PLR (20), and neutrophil-to-platelet ratio (21) in predicting disease activity may also increase the informative value of other cellular markers. In light of this information, the significantly higher WBC, neutrophil, platelet, NLR, RDW, PLR, and RPR results of UC patients compared to the control group in our study support the literature.

Anemia can result from iron deficiency due to reduced iron uptake from enterocytes, chronic diseases that inhibit erythropoiesis, or chronic blood loss from the gastrointestinal tract. In all three cases, it is difficult to treat, and for these reasons, anemia persists in many patients with UC even after one year of treatment. In the management of UC patients with anemia, it is important and useful to determine the type of anemia since treatment options depend on the type of anemia (22). The results of our patients with UC were similar to the literature; RDW values were high, Hb values were significantly lower and anemic compared to the control group, and although Hb values increased slightly after treatment, they continued to be anemic.

Among the various biochemical laboratory markers, serum CRP has received the most extensive study. A review evaluating biomarkers in children suggests that CRP is the most effective blood marker to differentiate IBD from IBS (23). The increase in CRP in the diagnosis or recurrence of UC is usually associated with a moderate increase in CRP, although this varies depending on the extent of the area involved (24). In the present study, we observed a significant increase in CRP levels in patients with UC, consistent with the findings reported in the literature. Our ROC analysis yielded a moderate cut-off value of 1.89 mg/L. Furthermore, our results demonstrated that the decline in CRP values of the UC group after treatment did not exhibit a statistically significant difference when compared to the control group.

Study limitations

Our study has some limitations. First of all, the main limitations of our study are that it was retrospective and single-centered with a small number of patients. In addition, our results could not be supported by a comparative analysis of current biomarkers such as FCal, SAA, and fecal matrix metalloprotease. Again, an endoscopic/histologic comparison of the usability of the four main findings of our study for the proof of remission in mucosal healing could not be made. Since these four parameters are likely to increase/decrease in every inflammatory process and the same inflammatory process is also present in UC patients, the predicted expectation was reflected in our results.

Conclusion

The results of our study suggest that, in cases where children present with gastrointestinal complaints and suspicion of IBD, referral to noninvasive procedures that are easy, inexpensive, and accessible, such as simple blood tests, may be a more appropriate course of action than pursuing a diagnosis with costly, difficult-to-access, invasive procedures. The presence of ESR and CRP elevation, as well as low levels of MCV and albumin, could serve as a triage tool for determining the necessity of histologic diagnosis. Nevertheless, it is our conviction that the findings of this study should be substantiated by the implementation of a more extensive and comprehensive series of studies.

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References

1. Benchimol EI, Fortinsky KJ, GozdyraP, et al. Epidemiology of pediatric inflammatory bowel disease: a systematic review of international trends. Inflamm Bowel Dis. 2011;17(1):423–39.
2. Kaplan GG, Ng SC. Understanding and Preventing the Global Increase of Inflammatory Bowel Disease. Gastroenterology 2017;152(2):313-21.
3. Carpi M, Jiménez S, Pujol G, et al. Time to diagnosis in paediatric inflammatory bowel disease: Key points for an early diagnosis. An Pediatr. 2020; 92:241-9.
4. Bossuyt PM, Irwig L, Craig J, et al. Comparative accuracy: assessing new tests against existing diagnostic pathways. BMJ. 2006;332(7549):1089–92.
5. Konikoff M.R, Denson L.A. Role of fecal calprotectin as a biomarker of intestinal inflammation in inflammatory bowel disease. Inflamm Bowel Dis. 2006; 12:524–34.
6. Daniluk U, Daniluk J, Krasnodebska M, et al. The combination of fecal calprotectin with ESR, CRP and albumin discriminates more accurately children with Crohn's disease. Adv Med Sci. 2019; 64:9–14.
7. Turner D, Ricciuto A, Lewis A, et al. STRIDE-II: An Update on the Selecting Therapeutic Targets in Inflammatory Bowel Disease (STRIDE) Initiative of the International Organization for the Study of IBD (IOIBD): Determining Therapeutic Goals for Treat-to-Target strategies in IBD. Gastroenterology 2021; 160:1570–83.
8. Wangchuk P, Yeshi K, Loukas A. Ulcerative colitis: clinical biomarkers, therapeutic targets, and emerging treatments. Trends Pharmacol Sci. 2024;45(10):892-903.
9. Turner D, Ruemmele FM, Orlanski-Meyer E, et al. Management of Paediatric Ulcerative Colitis, Part 1: Ambulatory Care-An Evidence based Guideline From European Crohn's and Colitis Organization and European Society of Paediatric Gastroenterology, Hepatology and Nutrition. J Pediatr Gastroenterol Nutr. 2018;67(2):257-91.
10. Pineton G, Peyrin L, Lemann M, et al. Clinical implications of mucosal healing for the management of IBD. Nat Rev Gastroenterol Hepatol. 2010; 7:15–29.
11. Coté CJ, Wilson S, American Academy of Pediatrics, et al. Guidelines for monitoring and management of pediatric patients before, during, and after sedation for diagnostic and therapeutic procedures. Pediatrics 2019;143: e20191000.
12. Thomson M, Tringali A, Dumonceau J-M, et al. Paediatric gastrointestinal endoscopy: European society for paediatric gastroenterology hepatology and nutrition and European society of gastrointestinal endoscopy guidelines. J Pediatr Gastroenterol Nutr. 2017; 64:133–53.
13. Weinstein TA, Levine M, Pettei MJ, et al. Age and family history at presentation of pediatric inflammatory bowel disease.J Pediatr Gastroenterol Nutr.2003;37:609–13.
14. Kucharzik T, Maaser C, Lugering A, et al. Recent understanding of IBD pathogenesis: implications for future therapies. Inflamm Bowel Dis. 2006; 12:1068–83.
15. Kucharzik T, Walsh SV, Chen J, et al. Neutrophil transmigration in inflammatory bowel disease is associated with differential expression of epithelial intercellular junction proteins. Am J Pathol. 2001; 159:2001–9.
16. Saverymuttu SH, Chadwick VS, Hodgson HJ. Granulocyte migrationin ulcerative colitis.Eur J Clin Invest. 1985; 15:60–3.
17. Dabek M, Ferrier L, Roka R, et al. Luminal cathepsin g and protease activated receptor 4: a duet involved in alterations of the colonic epithelial barrier in ulcerative colitis. Am J Pathol. 2009; 175:207–14.
18. Roseth AG, Fagerhol MK, Aadland E, et al. Assessment of the neutrophil dominating protein calprotectin in feces. A methodologic study. Scand J Gastroenterol. 1992; 27:793–8.
19. Roseth AG, Aadland E, Jahnsen J, et al. Assessment of disease activity in ulcerative colitis by faecal calprotectin, a novel granulocyte marker protein. Digestion 1997; 58:176–80.
20. Jeong Y, Jeon SR, Kim HG, et al. The role of platelet to lymphocyte ratio and neutrophil to lymphocyte ratio in ulcerative colitis. Intest Res. 2021; 19:62–70.
21. Yamamoto JK, Mendieta EA. Diagnostic utility of the neutrophil-platelet ratio as a novel marker of activity in patients with ulcerative colitis. PLoS ONE. 2020;15: e0231988.
22. Cronin CC, Shanahan F. Anemia in patients with chronic inflammatory bowel disease. AmJ Gastroenterol. 2001;96(8):2296-8.
23. Vermeire S, Van Assche G, Rutgeerts P. Laboratory markers in IBD: useful, magic, or unnecessary toys? Gut 2006; 55:426–31.
24. Saverymuttu SH, Hodgson HJ, Chadwick VS, et al. Differing acute phase responses in Crohn's disease and ulcerative colitis. Gut 1986; 27:809–13.

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Comparison of Oxidative and Antioxidative Parameters in The Exudative and Transudative Pleural Effusion

Eksuda ve Transuda Vasfındaki Plevral Sıvılarda Oksidatif ve Antioksidatif Parametrelerin Karşılaştırılması

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Abstract

Background: The initial step in diagnosing pleural effusion is to distinguish between transudate and exudate. In establishing this distinction, numerous parameters, particularly the Light criteria, have been utilized; however, there are instances where inaccurate results may arise. This study examined oxidative stress markers that may contribute in distinguishing between exudate and transudate fluids.

Materials and Methods: This study included 50 patients diagnosed with pleural effusion and 30 healthy individuals. The Total Oxidative Status (TOS) and Total Antioxidant Capacity (TAC) parameters were analyzed in pleural fluid and serum samples using the Erel technique on an Abbott Aeroset autoanalyzer in the biochemistry laboratory.

Results: The fluid TOS and TAC values in patients with the exudate group were higher than those in the transudate group ($p<0.005$). The exudate and transudate group exhibited elevated serum TOS levels in comparison to the control group ($p<0.005$). The serum TAC level in the control group was higher compared to the transudate and exudate groups. The serum (OSI) values in patients with exudative and transudative effusions were elevated compared to those in the control group. Serum OSI levels were significantly higher in exudative patients compared to both transudative patients and the control group ($p <0.001$).

Conclusions: Oxidative marker levels are significantly increased in exudative pleural effusions. In differentiating pleural fluid exudate from transudate, we determined that assessing the levels of TOS and TAC, utilized as oxidative stress indicators, may aid in diagnosis.

Keywords: Transudate, exudate, total oxidative status, total antioxidant capacity, oksidative stress index.

ÖZ

Amaç: Plevral efüzyonlarda, sıvının transuda eksuda ayrımının yapılması tanının ilk basamağını oluşturur. Bu noktada Light kriterleri başta olmak üzere pek çok parametre kullanılmıştır ancak bazen yanlış sonuçlar elde edilebilmektedir. Bu çalışmada sıvının transuda ve eksuda ayrımına katkı sunacağını düşündüğümüz oksidatif stres markırlarını araştırdık.

Gereç ve Yöntem: Çalışmaya plevral efüzyon tanılı 50 hasta ve 30 sağlıklı erişkin alındı. Biyokimya laboratuarında serum ve plevral sıvı örneklerinde, Abbot Aeroset marka oto analizör cihazında Erel metoduyla Total Oksidatif Seviye (TOS) ve Total Antioksidan Kapasite (TAK) parametrelerinin düzeyleri incelendi.

Bulgular: Eksuda vasıflı sıvısı olan hastalardaki sıvı TOS ve TAK değerleri, transudatif grubunun sıvı TOS ve TAK düzeylerine kıyasla daha yüksek idi ($p<0.005$). Eksuda ve transuda grubunun serum TOS düzeyleri, kontrol grubunun serum TOS düzeyine kıyasla daha yüksek idi ($p<0.005$). Kontrol grubunun serum TAK düzeyi, eksuda ve transuda grubunun serum TAK düzeylerine kıyasla daha yüksek idi. Eksudatif ve transudatif sıvılı hastaların serum OSI düzeyleri, kontrol grubunun serum OSİ düzeyine kıyasla daha yüksek idi. İstatistiksel olarak eksudalı hastalarda serum OSİ düzeyi, transudatif grup ve kontrol grubuna gore anlamlı oranda yuksek bulundu ($p <0,001$).

Sonuç: Eksuda vasıflı efüzyonlarda, oksidatif markır düzeylerinin artışının daha fazla olduğu görülmektedir. Oksidatif stres belirteci olarak kullanılan TOS ve TAK düzeyi ölçümünün plevral sıvı eksuda transüda ayrımında, tanıya katkı sunabileceği sonucuna vardık.

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Highlights

- Pleural fluid TOS and TAC levels are higher in exudative than transudative effusions, while serum TAC is highest in the control group compared to both effusion types.
- Serum TOS and OSI are higher in effusion groups, highest in exudates.
- Combined TOS, TAC, and OSI may aid in exudate–transudate differentiation.

Introduction

Pleural effusion is characterized by an abnormal accumulation of fluid in the pleural space and occurs due to an imbalance between the production and absorption of pleural fluid (1,2). Differentiating between exudative and transudative effusions is crucial, as the underlying mechanisms and subsequent treatment modifications rely on this distinction (3). To classify effusions as transudative or exudative, Lights criteria are most commonly utilized. Pleural effusions commonly result from increased hydrostatic pressure or decreased plasma colloid-osmotic pressure. Exudative effusions are typically associated with changes in pleural surface permeability resulting from inflammation, malignancy, or insufficient lymphatic drainage (4,5).

Normal metabolic processes in the body generate free radicals as a byproduct of oxygen utilization. Reactive oxygen derivatives can be detrimental to the organism if not converted to an inactive form or if produced in excessive amounts that exceed the body's defense mechanisms (6). Lipid peroxidation induced by reactive oxygen species can result in cell membrane dysfunction, diminished activity of membrane-bound receptors and enzymes, and heightened membrane permeability. The effects may significantly impact the development of various diseases. This condition is termed "Oxidative Stress," with the consequent harm identified as oxidative damage.

The body has antioxidant defense mechanisms that defend against the detrimental effects of reactive oxygen species. Antioxidants are classified into two primary categories: natural (endogenous) and exogenous antioxidants, as well as enzymatic and non-enzymatic antioxidants. Enzymatic antioxidants include mitochondrial cytochrome oxidase, superoxide dismutase (SOD), catalase, glutathione peroxidase (GSH-Px), glutathione transferase, prolidase and hydroperoxidase (7,8).

While non-enzymatic antioxidants are lipid-soluble α-tocopherol (vitamin E), β-carotene, and water-soluble ascorbic acid (vitamin C), along with melatonin, cysteine, ceruloplasmin, hemoglobin, and bilirubin (9). Exudative effusions are expected to exhibit significantly elevated oxidant levels and reduced antioxidant levels in comparison to transudative effusions. The objective of this study was to evaluate the variations in oxidant and antioxidant parameters in pleural fluid and serum, as well as to analyze the potential of TAC, TOS, and OSI as markers for differentiating between exudative and transudative pleural effusion.

Material and Methods

Study design

This prospective, single-center study was conducted at the Pulmonary Diseases Clinic at Harran University Hospital between January 2009 and July 2009. It included 50 patients with pleural effusion and 30 healthy individuals who formed the control group.

Pleural effusion was diagnosed through a thorough methodology that included physical examination, posteroanterior and left chest radiography, and, in certain instances, ultrasound imaging. Pleural fluid samples and peripheral venous blood specimens were collected from all patients diagnosed with pleural effusion. A volume of 40 mL of fluid was collected into a tube via the thoracentesis procedure. Peripheral venous blood samples were taken and kept in serum collection tubes. The biochemistry laboratory analyzed glucose, lactate dehydrogenase (LDH), total protein, albumin, cholesterol, and total bilirubin levels in pleural fluid and blood samples. Pleural fluid samples experienced cell count, gram staining, and non-specific culture analysis. The analysis of acid-fast bacilli (AFB) present staining the fluid using the Ziehl-Neelsen method and inoculating it onto Lowenstein-Jensen medium. The fluids were classified as exudates and transudates based on Light's criteria (8). The parameters referred to as "light criteria" are as follows (10):

a. Pleural protein to serum protein ratio (protein ratio) ≥ 0.5

b. Pleural LDH to serum LDH (LDH ratio) ≥ 0.6

c. Pleural LDH >200 U/lt or Pleural LDH >2/3 of the upper limit of the serum LDH

Fluids were classified as exudate if at least one of Light's criteria was met, and as transudate if none were met

(10).

Alongside Light's criteria, particularly in pleural effusions linked to congestive heart failure (CHF), the albumin gradient has been employed for transudate-exudate differentiation. (Albumin gradient: If serum albumin - pleural fluid albumin <1.2, it is classified as an exudate) (12).

The albumin gradient, particularly in instances involving diuretic use, has been shown to aid in the precise classification of pleural effusion (13).

This study classified patients based on their etiological diagnoses. Patients with exudative effusion caused tuberculosis, malignancy, parapneumonia, pericarditis, rheumatoid arthritis, hydatid cyst, or pulmonary embolism. In contrast, transudative effusion was due to congestive heart failure, liver cirrhosis, chronic kidney failure, or pulmonary embolism.

A 5-microliter sample was taken from the collected pleural fluid and blood samples to assess Total Oxidative Status (TOS), Total Antioxidant Capacity (TAC), and Oxidative Stress Index (OSI). Pleural fluid and blood samples were left at room temperature for 30-60 minutes before centrifugation at 3000-5000 × g for 10-15 minutes. Subsequently, serum and pleural fluid were separated using an automatic pipette. The samples were stored at -80 °C for the assessment of TOS, TAC, and Oxidative Stress Index (OSI). Upon obtaining a sufficient number of samples, the sera and fluids were thawed and analyzed in the biochemistry laboratory utilizing an Abbot Aeroset autoanalyzer with the Erel method to assess TOS and TAC parameters (14,15).

The OSI value for each participant was calculated by proportionally relating TOS to TAC (16).

Statistical analysis

IBM (International Business Machines) SPSS 11.0 (SPSS Inc. Chicago USA) program was used for statistical analysis. The study data was evaluated using descriptive statistical methods, including the mean and standard deviation. In addition, Student's t-test and One-Way ANOVA were used to compare quantitative data between different groups. These statistical tests were only applied to parameters that indicated a normal distribution. Receiver Operating Characteristics (ROC) analysis was performed to assess the diagnostic efficacy of TAC and Oxidative Stress Index (OSI) levels in differentiating exudative and transudative pleural effusions. The Light criteria have been used to determine the cutoff points for differentiating between transudative and exudative pleural effusions. The results were assessed using a 95% confidence interval, with a significance level of $p < 0.05$.

Ethical Approval

The study approved by the Ethics Committee of Harran University Faculty of Medicine (number: HRU/19.06.10, date: 19.06.2009). Informed consent was obtained from all patients. All procedures were carried out in accordance with the Declaration of Helsinki.

Results

The study involved 50 patients with pleural effusion. Patients were categorized into two groups based on the Light criteria: the exudative pleural effusion group, comprising 30 patients (60.00%), and the transudative pleural effusion group, comprising 20 patients (40.00%). The exudate group consisted of 15 (50.00%) malignancies, 3 (10.00%) cases of parapneumonia, 6 (20.00%) cases of tuberculosis, 2 (6.67%) cases of pericardial disease, 2 (6.67%) cases of pulmonary embolism, 1 (3.33%) case of rheumatoid arthritis, and 1(3.33%) case of hydatid cyst. The group of transudates included 16 (80.00%) cases of congestive heart failure, 1 (5.00%) case of chronic renal failure, 1 (5.00%) case of liver cirrhosis, and 2 (10.00%) cases of pulmonary embolism **(Table 1).**

Table 1. Patient distribution based on diagnoses.

Parameters	n, (%)	Parameters	n, (%)
Exudate	30(60)	**Transudate**	20(40)
Malignancies	15(26)	**Congestive Heart Failure**	16(32)
Tuberculosis	6(12)	**Chronic Renal Failure**	1(2)
Parapneumonia	3(6)	**Liver Cirrhosis**	1(2)
Pulmonary Embolism	2(4)	**Pulmonary Embolism**	2(4)
Others*	4(8)		

Abbreviations: * One patient with rheumatoid arthritis, one with a hydatid cyst, and two with pericardial disease.

Evaluation of the demographic data revealed no statistically significant difference in mean age among the exudate, transudate, and control groups (p>0.05) **(Table 2)**. Male patients were more prevalent in the group with exudative pleural effusion, compared to patients with transudative pleural effusions and the control group. However, there was no significant difference between groups for sex distribution (p> 0,05) **(Table 2).** There was no significant difference in smoking status between the exudate, transudate and the control group (p> 0,05) (**Table 2)**.

Table 2. Demographic data of patients

Variables	Exudate (n=30)	Transudate (n=20)	Control (n=30)	P
Gender, (M/F)	22 / 8	10 / 10	18 / 12	> 0.05
Age, (Years)	54.0 ± 14.07	56.80 ± 15.97	52.17 ± 9.91	> 0.05
Weight (kg)	69.07 ± 7.99	66.10 ± 7.88	70.07 ± 7.93	> 0.05
Smoking, (Yes/No)	17 / 13	9 / 11	14 / 16	> 0.05

When the LDH level of pleural fluid is set at an upper limit of 200 IU based on Light's criteria, it was found that the LDH values of 2 cases with transudative fluid had levels higher than 200. Furthermore, when the cut-off value for the pleural fluid/serum LDH ratio was set as 0.6, it was found that all cases classified as transudative had values below this value **(Table 3)**. When the cut-off value for the ratio of pleural fluid to serum total protein is set at 0.5, it was found that all cases classified as exudate had values higher than this threshold. In contrast, all cases classified as transudate had values lower than this threshold **(Table 3)**.

Table 3. Diagnostic value of Light's criteria in differentiating the transudate and exudate.

Variables	PE LDH >200	PE LDH <200	PE / Serum LDH >0.6	PE / Serum LDH <0.6	PE / Serum Protein >0.5	PE / Serum Protein <0.5
Exsudat	30	-	30	-	30	-
Transudate	2	18	-	20	-	20

Abbreviations: LDH: Lactate dehydrogenase

In the study group, the serum TOS levels of patients with exudative and transudative effusions were compared to those of the control group. The results revealed that both exudative and transudative patients had higher serum TOS levels than the control group. (p<0.001) **(Table 4, Figure 1A)**. Additionally, serumTOS levels were significantly higher in the exudative patient group compared to the transudative group. (p<0.001) **(Table 4, Figure 1A)**.

Table 4. Comparison of TAC, TOS and OSI values in exudate, transudate and control serums.

Parameters	Exudate (n=30)	Transudate (n=20)	Control (n=30)	p
TAC (mmol Trolox Eqv:/L)	0.79 ± 0.14	0.92 ± 0.12 ^{a***}	1.02 ± 0.12^{b***}, c***	<0.001
TOS (µmol H2O2 Eqv./L)	33.43 ± 14.15	21.20 ± 8.93 ^{a***}	19.55 ± 8.95 ^{b***}	<0.001
OSI (Arbitrary Unite)	4.18 ± 1.59	2.37 ± 1.15 ^{a***}	1.93 ± 0.89 ^{b***}	<0.001

Abbreviations: a: A significant difference exists between the exudative group and the transudative group. b: A significant difference exists between the exudative group and the control group. c: A significant difference exists between the transudative group and the control group. ***: p≤ 0.001, **: p≤0.01, *: p≤0.05

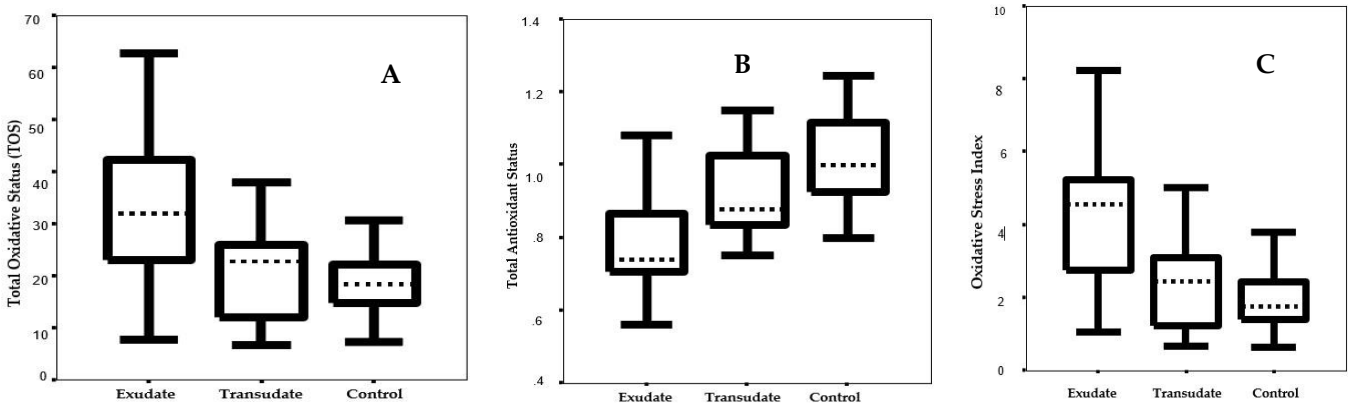

Figure 1. Comparison of TOS (A), TAC (B) and OSI (C) values in the distinction between exudate, transudate and control serums.

By comparing the levels of TAC in the blood samples from patients with exudative and transudative effusions to the control group, it was found that the TAC levels in the control group were higher than those in both the exudative and transudative patients **(Figure 1B)**. The exudate group had the lowest TAC levels ($p < 0.001$) **(Figure 1B)**.

In the study group, the serum OSI levels of patients with exudative and transudative effusions were compared to those of the control group. The results revealed that both exudative and transudative patients had higher serum OSI levels than the control group **(Figure 1C**). Additionally, serum OSI levels were significantly higher in the exudative patient group compared to the transudative group and the control group ($p < 0.001$).

By comparing the levels of TOS in the pleural fluid from the patients with exudate and transudate, it was found that the TOS levels in the exudative group were higher than the transudative group ($p < 0.001$) **(Table 5).**

By comparing the levels of TAC in the pleural fluid from the patients with exudate and transudate, it was found that the TAC levels in the exudative group were higher than the transudative group ($p < 0.001$) **(Table 5).**

Table 5. Comparison of fluid TAC, TOS and OSI values in the distinction between exudate and transudate.

Parameters	Exudate (n=30)	Transudate (n=20)	p
TAC (mmol Trolox Eqv:/L)	0.84 ± 0.17	0.79 ± 0.22	0.408
TOS (μmol H2O2 Eqv./L)	20.38 ± 13.02	11.70 ± 7.59	0.010
OSI (Arbitrary Unite)	2.43 ± 1.39	1.64 ± 1.14	0.040

By comparing the levels of OSI in the pleural fluid from the patients with exudate and transudate, it was found that the OSI levels in the exudative group were higher than the transudative group ($p < 0.001$) **(Table 5).**

We utilized ROC (receiver operating characteristic) analysis to assess the diagnostic performance of TAC and OSI, which show significant differences between exudative and transudative pleural fluids, in characterizing the properties of pleural fluid. Additionally, we assessed the diagnostic utility of both parameters by contrasting their levels in pleural fluid with serum values, as well as their effectiveness in differentiating exudative from transudative pleural effusions utilizing Light's criteria. The area under the ROC curve for serum OSI value was roughly 0.817, for pleural fluid it was 0.690, and for P/S OSI value it was 0.498. Therefore, serum OSI levels had the greatest diagnostic value for exudative effusions, with a 95% confidence interval of 0.70-0.94.

ROC curve analysis demonstrated an area under the curve of 0.183 for serum OSI, 0.310 for pleural fluid OSI, and 0.502 for the pleural fluid-to-serum OSI ratio. Accordingly, the ratio of pleural fluid OSI values to serum OSI values had the highest diagnostic value for identifying transudative fluids, with a 95% confidence interval of 0.33-0.67. However, the OSI values were not statistically significant in the diagnosis of pleural fluids characterized as transudate.

In the analysis of the ROC curve, the area under the curve for serum TAC value was found to be approximately 0.213, for pleural fluid it was 0.590, and for the P/S TAC value it was 0.753. Accordingly, the ratio of pleural fluid TAC values to serum TAC values has the highest diagnostic value for identifying exudative fluids, with a 95% confidence interval of 0.60-0.90 **(Figure 2A).**

The ROC analysis results for the transudate values we obtained were significantly distinct from those of the exudates. In these patients, the area under the curve for serum TAC value was 0.787, for pleural fluid it was 0.410, and for P/S TAC value it was 0.247. According to this, the serum TAC values have the highest diagnostic value for identifying transudative fluids with a 95% confidence interval of 0.66-0.91 **(Figure 2B).**

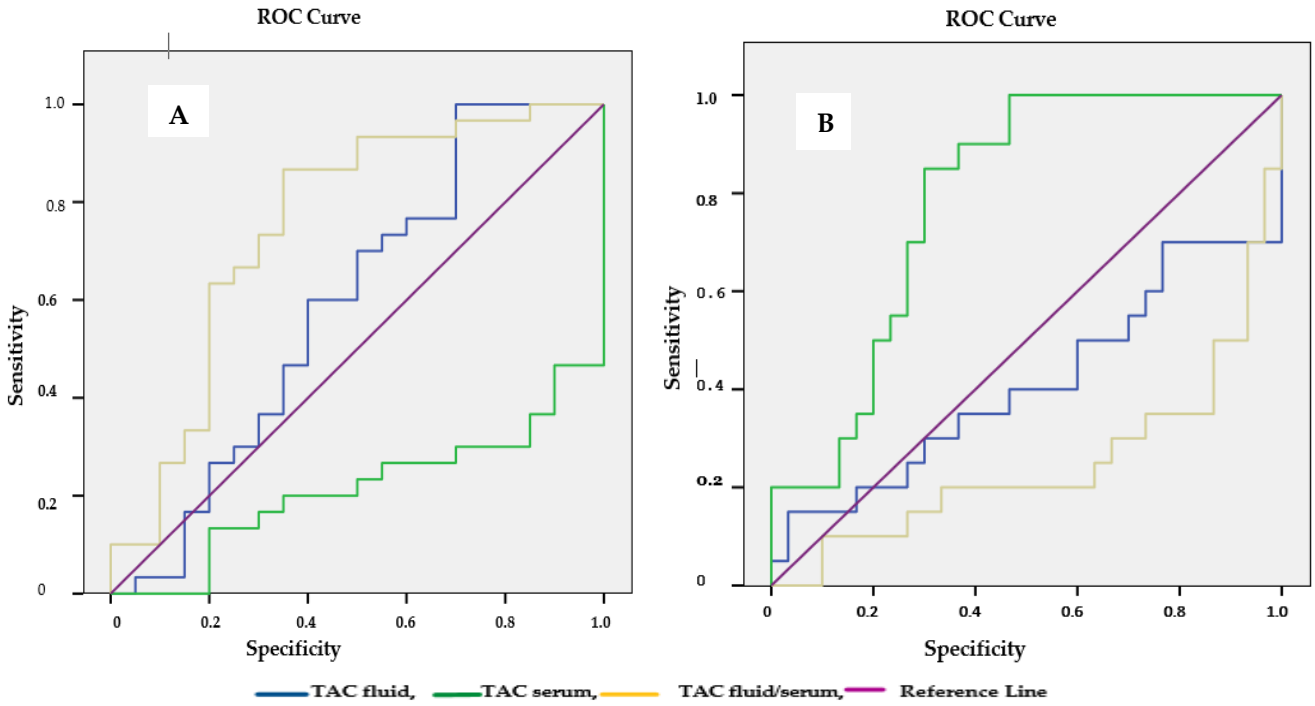

Figure 2. ROC analysis of TAC values in fluid and serum in patients with exudative (A) and transudate (B) fluid.

Discussion

Various parameters have been investigated to distinguish transudative from exudative pleural effusions, which may accumulate in the pleural space due to diverse etiologies. In 1972, Light et al. demonstrated that the differentiation of transudative from exudative pleural effusions could be enhanced using three parameters, which have since become known as Light's criteria (10). The current strategy for classifying pleural effusions is based on this criteria established by Light. In their analysis of 150 pleural effusions, all but one exudate had at least one of the three criteria, although only one transudate presented any of the three (10).

Burges et al. reported a sensitivity of 98% and a specificity of 83% in their study using Light's criteria for differentiating pleural effusions (17).

In the study conducted by Romeo and colleagues involving 297 patients with pleural effusion, when the fluids were classified as transudates or exudates based solely on the LDH parameter, the sensitivity was found to be 65.5%, specificity 100%, and accuracy 70.6% (18). In the present study, when fluids were categorized only by the LDH parameter, it was shown that the LDH levels in two transudate instances exceeded 200 U/L.

In their study utilising the P/S LDH ratio, Romero et al. misclassified 18.1% of transudates and 7.2% of exudates, yielding a sensitivity of 92.8%, specificity of 81.8%, and an accuracy of 91.1% (18). The present study indicated that when classified fluids based on the P/S LDH ratio, all transudate cases were below the 0.6 threshold, whereas all exudate cases above this limit.

Maranhao et al. investigated the significance of pleural LDH and total protein in differentiating between exudates and transudates, reporting sensitivities of 99.4% and 98.5%, and specificities of 72.6% and 83.4%, respectively (19). This study revealed that when fluids were categorized based on the P/S total protein ratio, all transudate cases were below the 0.5 cut-off value, whereas all exudate cases exceeded this threshold.

Heffner and colleagues conducted a meta-analysis involving 14,448 patients across 11 studies, yielding the following results for the Light criteria: P/S LDH ratio >0.6 demonstrates 88% sensitivity and 81.8% specificity; P/S total protein ratio >0.5 exhibits 89.5% sensitivity and 90.9% specificity; and pleural LDH > 2/3 of the upper limit of serum LDH shows 91.4% sensitivity and 85% specificity (20).

In recent years, additional parameters have been proposed for more reliably distinguishing transudates from exudates than Light's criteria, such as pleural fluid cholesterol level, pleural fluid to serum cholesterol ratio, alkaline phosphatase value, pleural fluid to serum cholinesterase ratio, and pleural fluid to serum bilirubin concentration ratio (21,22). However, all these alternative parameters still misclassified certain effusions, rendering their superiority over Light's criteria insignificant. Misclassifications predominantly occur in patients with congestive heart failure who are administered diuretics. In those with pleural effusion due to congestive heart failure, the

albumin gradient is utilized to distinguish between transudate and exudate (22). In this study, while no patients were undiagnosed based on total protein levels, the albumin gradients in all exudative cases were <1.2 g/dl. Two transudative cases with a fluid LDH level exceeding 200 U/L were correctly classified utilizing the albumin gradient. Both instances included patients utilizing diuretics for congestive heart failure (CHF).

Papageorgiou et al. assessed oxidative stress levels in pleural effusion fluid to differentiate between exudative and transudative effusions. Their studies revealed that oxidative stress levels were higher in exudative fluids compared to transudative fluids, and they reported that the correct diagnosis was established for 106 patients who had been misclassified according to the Light criteria utilizing their newly proposed marker. They stated that with this marker, a very high proportion of correct diagnosis was reached in the distinction of exudative and transudative pleural fluids, with 96.8% sensitivity and 96.3% specificity (22).

Erdoğan and colleagues concluded that longer stays in the intensive care unit and extended mechanical ventilation were associated with a significant decrease in serum total antioxidant levels, alongside significant increases in total oxidant levels, oxidative stress index, and prolidase levels (7).

Hammouda et al. studied malondialdehyde (MDA), a marker of free oxygen radical activity, in distinguishing between transudative and exudative pleural fluids, and found that the levels of MDA were higher in exudative pleural fluids compared to transudative fluids (23). Yadav et al. studied the levels of malondialdehyde (MDA), C-reactive protein (CRP), and uric acid in pleural fluid, compared the levels in exudative and transudative pleural fluid. MDA and CRP levels were significantly higher in the pleural fluid of the exudative type compared to the transudative type (24). These two studies shown that oxidative stress is more severe in exudates compared to transudates, probably because of the increased production of reactive oxygen species, which could serve as markers for distinguishing between exudates and transudates.

This study, similar to the previously stated studies, revealed that TOS levels were significantly higher in exudative pleural fluids in comparison to transudative fluids. Furthermore, it has been established that the TOS and OSI values in the serum of patients exhibiting exudative fluid characteristics are higher compared to the serum levels of patients with transudative fluid. The serum OSI values in patients with exudative fluid demonstrated significant diagnostic value, exhibiting a 95% confidence interval for exudate diagnosis.

In the study by Aydınoğlu et al. involving patients with parapneumonic pleural effusion, the blood TAC level in the control group was significantly higher than that in the exudate and transudate groups, with statistical significance observed (25). Liu et al. found increased DNA oxidative damage in the lymphocytes of cancer patients presenting malignant pleural effusion, alongside reduced TAC levels in their plasma (26). In our study group, the TAC values of patients with exudative fluid were lower than those of the transudative fluid group and the healthy control group. This circumstance may facilitate the identification of elevated OSI values in patients with exudative fluid.

This study analyzed the ratio of pleural fluid TAC levels to serum TAC levels. Based on the individual reflections of both parameters and their ratio, our ROC curve analysis established that it is a 95% reliable indicate for differentiating exudate from transudate in pleural fluid based on their ratio. The statistically significant ratio of antioxidants in pleural fluid compared to serum, along with the diagnostic utility in distinguishing exudative pleuritis from transudative pleuritis, suggests the possible incorporation of a new parameter in this domain. Nevertheless, this outcome requires validation through more comprehensive studies. In another study by Yadav et al, elevated levels of MDA and CRP were observed in the exudative fluid, indicating a direct correlation with the localized production of reactive oxygen species in the pleural exudate (24).

These results indicate that the increased level of inflammation in the pleura is mirrored by inflammatory markers in both the pleura and serum. The present study's findings indicate that oxidative stress levels are elevated in cases with exudative fluid. This spike may be ascribed to both the heightened inflammation in the fluid and the elevated serum oxidant levels in exudate-associated disorders comparative to other diseases.

Study limitations

The study has some limitations. The limited sample size (50 patients and 30 controls) and the single-center design might restrict the generalizability of the findings. Measurements obtained only using the Erel technique necessitate validation through alternative methods. In addition, there is an absence of follow-up data to investigate the long-term associations between clinical parameters and oxidative markers.

Conclusion

At the distinction between exudate and transudate the occasional insufficiency of Light's criteria necessitates the exploration of novel diagnostic approaches. This study revealed a notable elevation in TOS and OSI, markers of oxidative stress, in exudative fluids. The increased ratio of pleural fluid TAC levels to blood TAC levels observed among exudative patients was notably significant. These parameters may be used as an effective diagnostic instrument for differentiating exudate from transudate.

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References

1. Diaz-Guzman E, Dweik RA. Diagnosis and management of pleural effusions: a practical approach. Compr Ther. 2007;33(4):237-46
2. Gayen S. Malignant Pleural Effusion: Presentation, Diagnosis, and Management. Am J Med. 2022;135(10):1188-92.
3. Gautam S, K C SR, Bhattarai B, et al. Diagnostic value of pleural cholesterol in differentiating exudative and transudative pleural effusion. Ann Med Surg (Lond). 2022; 82:104479.
4. Robınson T, Scullıon J. Oxford handbook of respiratory nursing. Oxford University Press. 2021.
5. Krenke R, Maskey-Warzechowska M, Korczynski P, et al. Pleural Effusion in Meigs' Syndrome-Transudate or Exudate? Systematic Review of Literature. Medicine (Baltimore). 2015;94(49): e2114.
6. Ziaudeen S, Ravindran R. Assessment of Oxidant-Antioxidant Status and Stress Factor in Recurrent Aphthous Stomatitis Patients: Case Control Study. J Clin Diagn Res. 2017;11(3): ZC01-4.
7. Duran E, Baysal Z, Yalçın Ş, et al. Investigation of Oxidative Stress Parameters and Prolidase Enzyme Level Change in Mechanically Ventilated Patients in Intensive Care Unit. International Journal of Current Medical and Biological Sciences. 2022;2(1): 22-9
8. Tascanov MB, Tanriverdi Z, Gungoren F, et al. Relationships between paroxysmal atrial fibrillation, total oxidant status, and DNA damage. Rev Port Cardiol. 2021;40(1):5-10.
9. Akoglu G, Metin A, Kilinc F, et al. Total serum oxidant/antioxidant status and arylesterase activity in recurrent aphthous stomatitis. Ann Dermatol. 2013;25(3):273-7.
10. Light RW, Macgregor MI, Luchsinger PC, et al. Pleural effusions: the diagnostic separation of transudates and exudates. Annals of internal medicine. 1972; 77(4): 507-13.
11. Porcel JM. Identifying transudates misclassified by Light's criteria. Current opinion in pulmonary medicine. 2013; 19(4): 362-7.
12. Roth BJ, O' Meara TF, Cragun WH. The serum-effusion albumin gradient in the evaluation of pleural effusions. Chest 1990; 98: 546-49
13. Sandeesha V, Kiran CVR, Ushakiran P, et al. A comparative study of serum effusion albumin gradient and Light's criteria to differentiate exudative and transudative pleural effusion. Journal of Family Medicine and Primary Care. 2020; 9(9): 4847-52.
14. Erel O. A novel automated direct measurement method for total antioxidant capacity using a new generation, more stable ABTS radical cation. Clinical biochemistry. 2004; 37(4): 277-85.
15. Erel O. A new automated colorimetric method for measuring total oxidant status. Clinical biochemistry. 2005; 38(12): 1103-11.
16. Havlioglu S, Tascanov MB, Koyuncu I, Temiz E. The relationship among noise, total oxidative status and DNA damage. Int Arch Occup Environ Health. 2022;95(4):849-54.
17. Burgess LJ, Maritz FJ, Taljaard JF. Comparative analysis of the biochemical parameters used to distinguish between pleural transudates and exudates. Chest. 1995;107(69): 1604-9.
18. Romero S, Candela A, Martín C, et al. Evaluation of different criteria for the separation of pleural transudates from exudates. Chest. 1993; 104(2): 399-404.
19. Maranhão BH, Silva Junior CT, Chibante AM, et al. Determination of total proteins and lactate dehydrogenase for the diagnosis of pleural transudates and exudates: redefining the classical criterion with a new statistical approach. J Bras Pneumol. 2010;36(4):468-74.
20. Heffner JE, Brown LK, Barbieri CA, et al. Diagnostic value of tests that discriminate between exudative and transudative

pleural effusions. Chest. 1997; 111(4): 970-80.
21. Gupta KB, Ghalaut V, Gupta PP, et al. Efficacy of pleural fluid alkaline phosphatase and its ratio to serum levels in distinguishing exudates from transudates. Lung India. 2004; 21(4): 46-9.
22. Sandeesha V, Kiran CVR, Ushakiran P, et al. A comparative study of serum effusion albumin gradient and Light's criteria to differentiate exudative and transudative pleural effusion. Journal of Family Medicine and Primary Care. 2020; 9(9): 4847-52.
23. Khalil MM, Salem A. Lipid peroxidation products in pleural fluid for separation of transudates and exudates. Clinical chemistry. 1995; 41(9):1314-5.
24. Yadav A, Malathi M. Comparative Study of Transudate and Exudate Pleural Fluid Using C-reactive Protein, Uric Acid and Malondialdehyde as Markers. Indian Journal of Medical Biochemistry. 2019; 23(1): 193-6.
25. Aydinoğlu A, Çevik M, Boleken, ME et al. What is the Diagnostic Value of Plasma Antioxidative/Oxidative Status in Parapneumonic Effusions in Children? Türkiye Klinikleri Tip Bilimleri Dergisi. 2017; 37(4): 169-76.
26. Liu X, Zhao J, Zheng R. DNA damage of tumor-associated lymphocytes and total antioxidant capacity in cancerous patients. Mutation Research/Genetic Toxicology and Environmental Mutagenesis. 2003;539(1-2):1-8.

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Original Article

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Evaluation of Proton Pump Inhibitor Use of Patients Registered in Family Health Centers Regarding Rational Drug Use

Aile Sağlığı Merkezlerine Kayıtlı Hastaların Proton Pompa İnhibitörü Kullanımlarının Akılcı İlaç Kullanımı Açısından Değerlendirilmesi

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Abstract

Background: Proton Pump Inhibitors (PPIs) have become mainstay medications for acid-related gastrointestinal diseases like Gastro-Esophageal Reflux Disease and peptic ulcer disease. However, emerging data indicates potential adverse effects with long-term PPI use, including infections, fractures, kidney injury, vitamin deficiencies, and dementia. The aim of this study is to evaluate the prevalence, inappropriate use frequency, medication behaviors, and knowledge levels of PPI usage among patients presenting to family health centers in Samsun, Turkey.

Materials and Methods: This cross-sectional and prospective study was conducted over a 3-month period between December 1, 2022 and March 1, 2023. The data were collected with a questionnaire filled by face-to-face interviews.

Results: The study included 826 participants with a mean age of 44.5◙14.9 years. The PPI prescription rate was 60.8%, with 42.4% (n=213) having used PPIs in the past 8 weeks. The most common reason for use was concurrent medication effects (31.6%), heartburn (29.5%), and stomach pain (15.0%). Most (74.5%, n=615) had no Gastro-Intestinal (GI) complaints, and among those with complaints the median duration was 6 months (range 1-240 months).

Conclusions: The findings highlight the need for continued research and awareness efforts to curb the irrational use of these important medications, an emerging global public health crisis. Implementation of clinical practice guidelines can help optimize utilization, improve patient outcomes, and prevent serious side effects and drug interactions due to excessive use.

Keywords: Proton pump inhibitors, drug misuse, primary health care, drug prescriptions, education of patients

ÖZ

Amaç: Proton Pompası İnhibitörleri, Gastro-Özofageal Reflü Hastalığı ve peptik ülser hastalığı gibi asitle ilişkili Gastro-İntestinal hastalıklar için temel ilaçlar haline gelmiştir. Ancak, ortaya çıkan veriler enfeksiyonlar, kırıklar, böbrek hasarı, vitamin eksiklikleri ve bunama dahil olmak üzere uzun süreli Proton pompa inhibitörü kullanımıyla olası olumsuz etkilere işaret etmektedir. Bu çalışmanın amacı, Türkiye'nin Samsun kentindeki aile sağlığı merkezlerine başvuran hastalarda Proton pompa inhibitörü kullanımının yaygınlığını, uygunsuz kullanım sıklığını, ilaç davranışlarını ve bilgi düzeylerini değerlendirmektir.

Gereç ve Yöntem: Bu kesitsel ve prospektif çalışma, 01.12.2022 ile 01.03.2023 tarihleri arasındaki 3 aylık bir süre boyunca yürütülmüştür. Veriler yüz yüze görüşmelerle doldurulan bir anketle toplanmıştır.

Bulgular: Çalışmaya ortalama yaşları 44,5◙14,9 yıl olan 826 katılımcı dahil edilmiştir. PPİ reçete oranı %60,8'di ve bunların %42,4'ü (n=213) son 8 haftada PPİ kullanmıştı. Kullanımın en yaygın nedeni eş zamanlı ilaç etkileri (%31,6), mide ekşimesi (%29,5) ve mide ağrısı (%15,0) idi. Çoğunun (%74,5, n=615), Gİ şikâyeti yoktu ve şikâyeti olanlar arasında medyan süre 6 aydı (1- 240 ay).

Sonuç: Bulgular, ortaya çıkan küresel bir halk sağlığı krizi olan bu önemli ilaçların mantıksız kullanımını engellemek için sürekli araştırma ve farkındalık çabalarına ihtiyaç olduğunu vurgulamaktadır. Klinik uygulama kılavuzlarının uygulanması, kullanımı optimize etmeye, hasta sonuçlarını iyileştirmeye ve aşırı kullanımdan kaynaklanan ciddi yan etkileri ve ilaç etkileşimlerini önlemeye yardımcı olabilir.

Anahtar kelimeler: Proton pompası inhibitörleri, Uygunsuz ilaç kullanımı, Temel sağlık hizmeti, İlaç reçeteleri, Hastaların Eğitimi

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Highlights

- Inappropriate long-term use of PPIs was identified in more than half of recent users.
- More than half of the participants reported using PPIs, often without active GI symptoms.
- Notably, knowledge about the side effects and cost of PPIs was low.

Introduction

Proton pump inhibitors (PPIs) effectively suppress gastric acid secretion by blocking H+/K+-ATPase enzymes in parietal cells (1). Consequently, PPIs have become mainstay medications for acid-related gastrointestinal diseases like gastroesophageal reflux disease (GERD) and peptic ulcer disease. However, emerging data indicates potential adverse effects with long-term PPI use, including infections, fractures, kidney injury, vitamin deficiencies, and dementia (2).

Recent meta-analyses suggest PPIs increase risks of Clostridium difficile and other enteric infections by enabling pathogen survival from reduced gastric acidity (3,4). A 2021 meta-analysis reported a 73% higher C. difficile infection risk among PPI users versus non-users. Risks of recurrence or recurrent infections also increased with PPI exposure (5,6).

The relationship between PPIs and pneumonia remains contentious, with some meta-analyses suggesting increased risks while others note uncertainties from residual confounding. Proposed mechanisms center on facilitated gastrointestinal bacterial colonization, micro aspiration, and impaired immunity. Overall evidence linking PPIs with incident pneumonia is inconclusive (7-9).

Collagenous colitis and lymphocytic colitis manifesting as chronic diarrhea have recently been associated with PPI exposure too (10). Proposed explanations include PPI-induced changes in intestinal permeability, immunity, microbiome composition and intraluminal milieu. Up to 25% long-term PPI users can also develop benign gastric fundic gland polyps that often regress on discontinuation (11).

Various meta-analyses indicate inconsistent evidence between PPI exposure and increased fracture risks (12). Impaired calcium absorption from hypochlorhydria likely mediates PPI-associated fracture risks rather than direct skeletal effects. Because hepatic metabolism clears PPIs, impairment can augment bioavailability and toxicity. PPIs also frequently interact with clopidogrel, warfarin, methotrexate, and antivirals via cytochrome enzymes (2).

While biological plausibility and worrisome case reports link PPI-induced hypergastrinemia with gastric neuroendocrine tumors, population data show no consistent evidence between PPI exposure and incident gastric or colorectal cancers. Confidence remains low regarding causal associations between PPI use and incident neoplasms (13,14).

Inappropriate PPI overprescribing is common, with use without clear indications in up to 90% inpatients and 50% outpatients (15). Canadian and American gastroenterology societies emphasize deprescribing PPIs when benefits no longer outweigh potential harms of continued therapy, through reassessment of indications, dosing minimization, switching to alternative drugs like histamine receptor-2 antagonists, or gradual discontinuation. Such judicious use aids minimizing needless expense and consequences (2).

The aim of this study is to evaluate the prevalence, inappropriate use frequency, medication behaviors, and knowledge levels of PPI use among patients presenting to family health centers in Samsun, Turkey. It also aims to provide up-to-date data on rational PPI use to the literature through a real field study conducted at primary care clinics.

Material and Methods

Study design

This cross-sectional and prospective study was conducted over a 3-month period between 01.12.2022 and 01.03.2023. The study population consisted of individuals registered at Family Health Centers (FHC) affiliated with the Samsun Provincial Health Directorate. According to Turkish Statistical Institute (TUIK) data obtained from the Samsun Governor's Office, the population of Samsun was 1,335,716 as of 2018. Using the Raosoft program, sample size calculation with 5% acceptable error, 50% frequency, and 99% confidence interval required reaching at least 664 people. Considering the populations of central (Atakum, Canik, Ilkadim, Tekkekoy) and peripheral (Alacam, Asarcik, Ayvacik, Bafra, Havza, Carsamba, Ladik, Kavak, Ondokuzmayis, Salipazari, Terme, Yakakent, Vezirkopru) districts, two FHCs were visited in central districts (8 working days) and one FHC in peripheral

districts (13 working days). One full day (total 21 working days) visit was planned for each FHC. Reviewing the registered population data from the Samsun Provincial Health Directorate, the busiest FHCs were selected based on district population. Target enrollment from each FHC was determined considering district populations, with 50 participants from central district FHCs and 16, 12, 12, 88, 24, 88, 10, 14, 16, 16, 42, 6, 56 participants, respectively, from the peripheral district FHCs listed above, totaling 800 targeted participants. Simple random sampling was used. Patients participated voluntarily.

To obtain participants' sociodemographic and clinical data, a 35-item questionnaire was administered face-to-face to collect information on age, sex, marital status, education, occupation, household size, income level, knowledge of acid suppressants, their prices, side effects, interactions, need for prescription, appropriate timing and dosage, how treatment was initiated and continued, prescribing clinician and indication, insurance coverage, where prescriptions were filled, lifestyle modification recommendations, follow-up after initiation, and treatment cessation. The 8-week period was used to define long-term PPI use (16). The questionnaire was developed using relevant literature. Participant income levels were compared to November 2022 data from the Turkish Confederation of Labor Unions (hunger line 7786 ₺ (◎418 $), poverty line 25364 ₺ (◎1362 $)) since 2022 TUIK data was unavailable at the time of the study considering recent high inflation. Each form took approximately 8-10 minutes to complete through face-to-face interviews. Participants received no financial compensation.

Inclusion criteria were presented to the designated FHCs during the specified dates and being age 18 or older. Exclusion criteria were failure to complete the interview and communication disorders that could impede participation.

Statistical analysis

Data was analysed using SPSS version 25.0. Frequency distributions and mean ± standard deviation were calculated for parametric data and median (minimum-maximum) for non-parametric data. Chi-square and Fisher's exact tests were used to compare categorical variables. The level of statistical significance was accepted as $p<0.05$. The sample size study was calculated using the Raosoft program with a 5% acceptable error, 50% frequency, and 99% confidence interval, and it was determined that at least 664 individuals needed to be included. The relationships between PPI use and education level, income status and presence of a health professional in the family were assessed using the chi-squared test.

Ethical approval

The study protocol was approved by the Samsun Provincial Health Directorate on November 10, 2022, and the Samsun University Clinical Research Ethics Committee. (Number: SUKAEK-2022-12/7 date :23.11. 2022. The study was conducted in accordance with the Declaration of Helsinki and good clinical practice principles. Participants provided informed verbal consent after receiving detailed information about the study.

Results

The study included 826 participants with a mean age of 44.5±14.9 years. Over half (54.1%) were male, 74.7% were married, and 33.5% had a secondary education. Most participants were below the poverty line. 25% of participants had a relative who was a healthcare worker. Urban and rural participant selection was approximately equal. The characteristic features of the participants are shown in **Table 1**.

Table 1. Characteristic features of the participants

Participant Characteristics	**n (%)**
Mean age (years)	44.5 ± 14.9
Gender	
- Male	447 (54.1)
- Female	379 (45.9)
Marital status	
- Married	617 (74.7)
- Single	209 (25.3)

Education level	
- Primary school	270 (32.7)
- Secondary school	277 (33.5)
- University	252 (30.5)
- Graduate degree	27 (3.3)
Monthly income per capita	
- Below poverty line (<7786 TRY / (~418 $))	501 (60.7)
- Above poverty line (≥7786 TRY / (~418 $))	325 (39.3)
Healthcare worker family member	209 (25.3)
Region	
- Urban	407 (49.2)
- Rural	419 (50.8)

The PPI usage rate was 60.8% (n=502), with 42.4% (n=213) having used PPIs in the past 8 weeks. Just over half (53.5%, n=269) reported inappropriate long-term PPI use (>8 weeks). Most (74.5%, n=615) had no Gastro-Intestinal (GI) complaints, and among those with complaints the median duration was 6 months (range 1-240 months). The most reported complaint was gastroesophageal reflux (46.0%). Among current or prior users, 82.7% required no dose reductions, and 94.8% began using via prescription. The specialty that most frequently prescribed PPIs was Family Medicine, and the healthcare institution that most frequently prescribed PPIs was Family Health Centers. While 71.6% obtained PPIs from family health centers, 93.6% obtained them using a prescription and 64.8% would not use without a doctor's recommendation. Those with lower education levels and no healthcare worker family members were more likely to use PPIs without a recommendation (both $p<0.001$). **Table 2** shows PPI use patterns and prescribing details.

Table 2. PPI use patterns and prescription characteristics among participants

PPI Use Patterns and Prescribing Details	n (%)
Used PPIs in the past 8 weeks	213 (42.4)
Inappropriate long-term use (>8 weeks)	269 (53.5)
Previous or current PPI use	291 (47.3)
Most common reasons for use	
- Concurrent medications	178 (31.6)
- Heartburn	166 (29.5)
- Stomach pain	84 (15.0)
Having GI complaints	211 (25.5)
- Gastroesophageal reflux	97 (46.0)
- Gastritis	53 (25.1)
- Ulcer	47 (22.3)
Most common prescribing specialties	
- Family medicine	181 (37.8)
- Internal medicine	149 (31.1)
- Gastroenterology	26 (5.4)
- General surgery	25 (5.2)
Most common prescribing locations	
- Family health centers	343 (71.6)
- Public hospitals	124 (25.9)
- Private facilities	10 (2.1)
- University hospitals	2 (0.4)

Most participants (66.0%) were unaware of PPI costs. Of those who were aware, 72.6% felt prices were expensive. Responses differed significantly by income level ($p<0.001$), with higher income associated with lower perceived expensiveness. Most (86.7%) felt PPIs should only be used with a doctor's recommendation, though 33.1% admitted

advising others to use PPIs. Those with a healthcare worker family member were significantly less likely to make recommendations compared to others (57.4% vs 70.2%, p<0.001). Recommendation frequency also differed significantly by education level (p=0.002), with a linear trend of decreasing recommendations with higher education. Only 38.0% believed PPIs have side effects, most commonly nausea. Those perceived side effects were more likely to advise others (p<0.001) but not more likely to believe doctor consultation is necessary (p=0.060). Most (86.3%) felt PPIs should be taken before meals and 71.1% felt dosages should remain constant during treatment. Approximately half (52.7%) reported no prior PPI use. The most common reasons for use were concurrent medication effects (31.6%), heartburn (29.5%), and stomach pain (15.0%). There were no significant differences in PPI patterns between central and peripheral regions (p=0.852). Knowledge and attitudes about PPI use are shown in **Table 3**.

Around two-thirds (68.5%) were also counseled on lifestyle changes, most often by family medicine. Only 35.7% were asked to return for follow-up, with 70.2% returning within 1 month, most often by internal medicine. Just over half reported previously self-discontinuing PPI treatment, while 35.7% had treatment stopped by a doctor, most commonly within 1 month. Information on PPI usage follow-ups, discontinuation of treatment and duration of use are given in **Table 4**.

Tablo 3. PPI Perspectives, Knowledge, and Behaviors

PPI Perspectives, Knowledge, and Behaviors	**n (%)**	***p***
Unaware of PPI costs	545 (66.0)	
Perceive PPI costs as expensive	204 (72.6)	
Income Level Association with Perceived Expensiveness		x^2=34.536, *p<0.001*
Use PPIs without doctor's recommendation	176 (35.2)	
Began PPI use via prescription	476 (94.8)	
Obtain PPIs with prescription	468 (93.6)	
Obtain PPIs without doctor's recommendation	176 (35.2)	
Obtain PPIs from family health centers	343 (71.6)	
Recommend PPIs to others	273 (33.1)	
Association Between Perceiving Side Effects and Recommending		x^2=26.086, *p<0.001*
Association Between Having Healthcare Worker Family Member and Recommending		x^2=11.491, *p<0.001*
Association Between Education Level and Recommending		x^2=15.294, *p=0.002*
Unaware if PPIs are similar	315 (38.1)	
Believe PPIs interact with other medications	219 (26.5)	
Believe PPIs have side effects	314 (38.0)	
Most Reported Side Effects		
- Nausea	21 (16.0)	
- Diarrhea	18 (13.7)	
- Headache	13 (9.9)	

Tablo 4. PPI Follow-up, Discontinuation, and Duration

PPI Follow-up, Discontinuation, and Duration	**n (%)**
Counseled on lifestyle changes with PPI prescription	328 (68.5)
Asked to return for PPI follow-up	171 (35.7)
Returned within 1 month if asked	120 (70.2)
Frequency of specialties calling for follow-up	
- Internal medicine	63 (36.8)
- Family medicine	37 (21.6)
Self-discontinued PPI treatment	277 (55.2)
Doctor stopped PPI treatment	171 (35.7)
Doctor stopped within 1 month	120 (70.2)
PPI treatment duration (weeks) (median)	12 (1-1560)

Discussion

PPIs are among the most prescribed drug classes globally (16). They revolutionized the treatment of acid-related gastrointestinal diseases. PPIs are widely used for GERD, dyspepsia, H. pylori infection, Barrett's esophagus, eosinophilic esophagitis and prevention of NSAID-induced gastric bleeding (17). As per recent data, PPIs constitute 9.2% of all prescription drug expenditure in the US (18). In Turkey, PPI prescription rates exceed 31 million annually, constituting significantly high expenditure (19). This situation leads to excessive healthcare expenditures and necessitates rational PPI prescribing. In our study, we aimed to evaluate the prevalence of PPI prescriptions, compliance with standard indications and durations, and patient perspectives from family medicine centers in Samsun province.

Our results show that personal use of PPIs is high (60.8%) for mostly inappropriate indications or duration. According to studies in the literature, this situation can be defined as irrational (20,21). These real-world insights provide valuable data for health policymakers to implement stewardship programs promoting rational use. Literature shows inappropriate PPI use in 27-80% hospitalized patients and 36-63% primary care patients (7). Hence, improving appropriate PPI prescribing at primary care facilities, the common first point-of-care is essential. The strength of this field-based study is the diversity of participants across Samsun districts, enabling capture of rural-urban differences. The limitations include single-city design, exclusion of children, and comparison of income status with 2022 inflation-affected data. Further studies must explore generalizability in other provinces and pediatric subgroups. Natural experiments measuring the impact of de-prescribing efforts would also inform future policy measures.

Awareness and practice change interventions have successfully improved guideline-concordant PPI use (22). Strategies include education for providers and patients (23), use of electronic decision tools integrating guidance (24), structured patient reviews for de-prescribing, and policy measures limiting over-the-counter availability. Increased physician access through strengthening primary healthcare workforce and infrastructure would also enable adequate patient education and medication reviews during visits.

In our study, 92% of patients obtained PPIs only with prescriptions, and most would stop treatment on physician advice, showing community openness to professional recommendations. Family physicians constituted common prescribers; hence workforce training should engage this vital group (25). Implementation of evidence-based, multipronged strategies adapted for the local health systems context could promote appropriate PPI prescribing.

Study limitations

The limitations of this study include single city setting, exclusion of pediatric population, COVID-19 pandemic affecting routine outpatient flow, and income levels compared to Turkish Statistical Institute 2021 data as 2022 data was unavailable. The strengths are province-wide representative sampling based on population density across districts, real-world field study, and one of few studies from primary care settings.

Conclusion

In conclusion, our study provides valuable insights into PPI prescription prevalence, inappropriate use, patient knowledge and behaviors regarding these important medications. The findings highlight the need for continued research and awareness efforts to curb the irrational use of PPIs, an emerging global public health crisis. Implementation of clinical practice guidelines can help optimize utilization, improve patient outcomes and prevent serious side effects and drug interactions due to excessive PPI use.

At this stage, given the potential side effects and problems associated with overuse of PPIs, their prescription should be regulated using a stepwise approach. The most effective way to address high rates of inappropriate PPI use is through primary care physicians, who are the first point of contact for patients and can provide quick and easy care. For patients with long-term PPI use and chronic conditions, prescriptions should be issued by internal medicine departments; for patients with a history of or need for surgery, PPI prescriptions should be issued by surgical specialties.

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References

1. Sachs G, Shin JM, Briving C, et al. The pharmacology of the gastric acid pump: the H+, K+ ATPase. Annu Rev Pharmacol Toxicol. 2018; 58:277-305.
2. Moayyedi PM, Andrews CN, MacQueen G, et al. Canadian Association of Gastroenterology Clinical Practice Guideline for the Management of Irritable Bowel Syndrome (IBS). J Can Gastroenterol. 2019; 2(1):6-9.
3. Kwok CS, Arthur AK, Anibueze CI, et al. Risk of Clostridium difficile infection with acid suppressing drugs and antibiotics: meta-analysis. Am J Gastroenterol. 2012; 107:1011-9.
4. Oshima T, Wu L, Fukui H, et al. Magnitude and direction of the association between Clostridium difficile infections and proton pump inhibitors in adults and pediatric patients: a systematic review and meta-analysis. J Gastroenterol. 2018; 53:84-94.
5. D'Silva KM, Mehta R, Mitchell M, et al. Proton pump inhibitor use and risk for recurrent Clostridioides difficile infection: a systematic review and meta-analysis. Clin Microbiol Infect. 2021; S1198-743X (21)00035-5.
6. Brisebois S, Merati A, Gilberto JP. Proton pump inhibitors: Review of reported risks and controversies. Laryngoscope Investig Otolaryngol. 2018;3(6):457-62.
7. Eom CS, Jeon CY, Lim JW, et al. Use of acid-suppressive drugs and risk of pneumonia: a systematic review and meta-analysis. CMAJ. 2011; 183:310-9.
8. Xun X, Yin Q, Fu Y, et al. Proton pump inhibitors and the risk of community-acquired pneumonia: an updated meta-analysis. Ann Pharmacother. 2022;56(5):524-32.
9. Wang CH, Li CH, Hsieh R, et al. Proton ump inhibitors therapy and the risk of pneumonia: a systematic review and meta-analysis of randomized controlled trials and observational studies. Expert Opin Drug Saf. 2019;18(3):163-72.
10. Farcas RA, Grad S, Dumitrascu DL. Microscopic colitis: an update. Med Pharm Rep. 2022;95(4):370-6.
11. Jalving M, Koornstra JJ, Wesseling J, et al. Increased risk of fundic gland polyps during long-term proton pump inhibitor therapy. Aliment Pharmacol Ther. 2006; 24:1341-8.
12. Yu EW, Bauer SR, Bain Paet al. Proton pump inhibitors and risk of fractures: a meta-analysis of 11 international studies. Am J Med. 2011;124(6):519-26.
13. Zheng Z, Lu Z, Song Y. Long-term proton pump inhibitors use and its association with premalignant gastric lesions: a systematic review and meta-analysis. Front Pharmacol. 2023; 14:1244400.
14. Poly TN, Lin MC, Syed-Abdul S, et al. Cancers. 2022;14(13):3052.
15. Muheim L, Signorelli A, Markun S, et al. Potentially inappropriate proton-pump inhibitor prescription in the general population: a claims-based retrospective trend analysis. Therap Adv Gastroenterol. 2021; 14:1756284821998928.
16. Farrell B, Lass E, Moayyedi P, et al. Reduce unnecessary use of proton pump inhibitors. BMJ. 2022;379: e069211.
17. Jaynes M, Kumar AB. The risks of long-term use of proton pump inhibitors: a critical review. Ther Adv Drug Saf. 2019; 10:2042098618809927.
18. Reichert S, Simon T, Halm EA. Physicians' attitudes about prescribing and knowledge of the costs of common medications. Arch Intern Med. 2000;160(18)2799-803.
19. Bilgener E. The effect of proton pump inhibitor consumption on budget in Turkey between 2006-2011. J Fac Pharm Ankara. 2018;42(2):23–31.
20. Kinoshita Y, Ishimura N, Ishihara S. Advantages and disadvantages of long-term proton pump inhibitor use. J Neurogastroenterol Mot. 2018;24(2):182-96.
21. Wu CC, Fang CY, Yu BH, et al. Long-term usage of proton pump inhibitors associated with prognosis in patients with colorectal cancer. Cancers. 2023;15(21):5304.
22. Farrell B, Pottie K, Thompson W, et al. Deprescribing proton pump inhibitors: evidence-based clinical practice guideline. Can Fam Physician. 2017;63(5):354–64.
23. Tannenbaum C, Martin P, Tamblyn R, et al. Reduction of inappropriate benzodiazepine prescriptions among older adults through direct patient education: The EMPOWER cluster randomized trial. JAMA Intern Med. 2014;174(6):890–8.
24. Madden JM, Lakoma MD, Rusinak Det al. Missing clinical and behavioral health data in a large electronic health record (EHR) system. J Am Med Inform Assoc. 2016;23(6):1143–9.
25. Ozturk O, Goktepe ME, Buyukkaya, Pet al. A family medicine routine: your disease is related to the stomach, not the heart. IJCMBS. 2021;1(2):69-71.

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Are Forensic Reports More Complete During Night Shifts? A Retrospective Study from a Secondary Hospital in Türkiye

Gece Vardiyalarında Adli Raporlar Daha Eksiksiz mi? Türkiye'de İkinci Basamak Bir Hastanede Yapılan Retrospektif Bir Çalışma

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Abstract

Background: This study aimed to evaluate the completeness of forensic medical reports prepared in the emergency department and to investigate how documentation rates vary according to shift hours (in-hours vs. out-of-hours) and the presence of life-threatening conditions. The goal was to identify shortcomings in forensic reporting practices and to provide insights for improving the quality and consistency of medico-legal documentation.

Materials and Method: This retrospective, single-center study was conducted in the emergency department of a secondary-level hospital in Sinop, Türkiye. Forensic cases admitted between May 1 and August 1, 2019, were analyzed. Data on patient demographics, shift hours (in-hours vs. out-of-hours), and completeness of various sections of forensic reports were collected and compared.

Results: A total of 311 forensic cases were included. Reports prepared during out-of-hours shifts had significantly higher completion rates in multiple sections, including complaints, past medical history, psychiatric evaluation, performed tests, and body diagrams. Patients without life-threatening conditions had more complete documentation in past medical history and psychiatric sections, while simple medical intervention notes were more frequently completed in life-threatening cases.

Conclusions: Shift hours significantly affect the completeness of forensic reports, with better documentation observed during out-of-hours shifts. Life-threatening conditions may reduce the thoroughness of documentation in certain report sections. Improving training and standardizing report protocols may enhance report quality across all settings and times.

Keywords: Emergency Department, Forensic Medicine, Medico-Legal Documentation, Forensic Report Completeness , Documentation Quality

ÖZ

Amaç: Bu çalışmanın amacı, acil serviste hazırlanan adli tıbbi raporların eksiksizliğini değerlendirmek ve dokümantasyon oranlarının vardiya saatlerine (mesai içi ve mesai dışı) ve yaşamı tehdit eden durumların varlığına göre nasıl değiştiğini araştırmaktır. Hedef, adli raporlama uygulamalarındaki eksiklikleri tespit etmek ve medikolegal dokümantasyonun kalitesini ve tutarlılığını artırmak için içgörüler sağlamaktır.

Gereç ve Yöntem: Bu retrospektif, tek merkezli çalışma, Sinop'taki ikinci basamak bir hastanenin acil servisinde yürütülmüştür. 1 Mayıs – 1 Ağustos 2019 tarihleri arasında adli nedenlerle başvuran hastalar incelenmiştir. Hasta demografik bilgileri, başvuru saatleri (mesai içi ve dışı) ve adli rapor bölümlerinin doldurulma durumu değerlendirilmiştir.

Bulgular: Toplam 311 adli olgu çalışmaya dahil edilmiştir. Mesai dışı saatlerde düzenlenen raporların şikâyet, özgeçmiş, psikiyatrik değerlendirme, yapılan tetkikler ve vücut şeması gibi bölümlerde anlamlı şekilde daha yüksek tamamlanma oranlarına sahip olduğu saptanmıştır. Yaşamsal tehlikesi olmayan olgularda özgeçmiş ve psikiyatrik değerlendirme bölümleri daha eksiksiz doldurulmuş, yaşamsal tehlike bulunan olgularda ise basit tıbbi müdahale ile giderilebilirlik notu daha sık kaydedilmiştir.

Sonuç: Adli raporların tamamlanma düzeyi, mesai saatlerinden anlamlı şekilde etkilenmektedir; mesai dışı saatlerde daha ayrıntılı belgeler hazırlanmıştır. Yaşamsal tehlike varlığı, bazı rapor bölümlerinin eksik kalmasına neden olabilmektedir. Hekim eğitimlerinin artırılması ve standart raporlama protokollerinin uygulanması, her zaman diliminde rapor kalitesini artırabilir**.**

Anahtar kelimeler: Acil Servis, Adli Tıp, Mediko-Legal Dokümantasyon, Adli Rapor Tamlığı , Dokümantasyon Kalitesi.

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Highlights

- Out-of-hours reports were more complete than in-hours reports.
- Life-threatening cases had less complete documentation in some sections.
- Standardized protocols and physician training can improve report quality.

Introduction

Emergency department (ED) often represent the first point of contact for individuals involved in assaults, traffic accidents, occupational injuries, self-harm, or other situations necessitating forensic evaluation. In such cases, the quality and comprehensiveness of forensic reports are critical not only for the legal process but also for the protection of individual rights and the prevention of medical-legal disputes (1-3).

In Türkiye, physicians working in ED are legally obliged to prepare forensic examination reports in cases involving injuries with potential legal relevance. These reports are expected to include a wide range of components such as a detailed anamnesis, complaint and physical examination findings, assessment of vital systems, psychological evaluation, any tests or imaging performed, and the presence or absence of life-threatening conditions. Additionally, elements such as the suitability of the examination environment and the presence of third parties during the examination are also supposed to be documented in accordance with medico-legal standards (4, 5).

Despite these structured expectations, there is considerable variability in the content and completeness of forensic documentation, which may be influenced by multiple factors. These include physician workload, time of day, institutional protocols, availability of forensic expertise, and the nature or severity of the incident (6). Particularly during out-of-hours shifts, increased patient volume and reduced staffing may compromise the attention given to medico-legal documentation, which can ultimately affect the legal value and usability of the report (4, 7).

Although there are several studies in the literature focusing on forensic case characteristics and documentation quality in EDs, most of them have been conducted in tertiary or university hospital settings located in major cities. Data on the completeness and quality of forensic reports from smaller provinces in Türkiye remain limited.

This study aimed to analyze the forensic cases presenting to the emergency department of a secondary-level state hospital in Sinop, Türkiye. By comparing the documentation quality during in-hours and out-of-hours admissions and investigating differences based on life-threatening status, this study seeks to identify patterns and potential areas for improvement in forensic medical reporting in the ED setting.

Material and Methods

Study Design

This study was a retrospective, single-center, observational analysis conducted in the ED of a second-phase state hospital in Sinop, Türkiye. This hospital primarily serves approximately 200,000 residents annually. Patients admitted between 1 May 2019 and 1 August 2019 and whose admission was accepted as forensic were included in the study.

Selection of participants and study protocol

According to Turkish law, forensic cases include assault, injuries, accidents (traffic, domestic, occupational), burns, poisoning, asphyxia, torture, suicide attempts, suspicious sudden deaths, and similar conditions requiring forensic examination (1, 8). Forensic examination reports in Türkiye typically include sections regarding the suitability of the examination environment, the presence of other individuals during the examination, patient anamnesis, current complaints, past medical history, consultation requests, lesion findings, system-based examinations, psychiatric evaluations, laboratory and imaging tests, and body diagrams. Physicians practicing in Türkiye are legally obliged to participate in the evaluation of forensic cases in accordance with the Law on the Practice of Medicine and Medical Specializations (9), and they are also mandated by Article 280 of the Turkish Penal Code to report forensic incidents to the relevant authorities (8). In Türkiye, working hours from 08:00 to 17:00 are considered 'in-hours,' during which most public and private-sector employees are on duty.

The acceptance of the hospital admission as a forensic admission was considered an inclusion criterion, and the inaccessibility of patient data was considered an exclusion criterion. Twelve patients whose documentation could not be retrieved were excluded from the analysis. The need for signed informed consent was waived due to the retrospective design of the study.

Each forensic report section was assessed individually for completeness. A binary approach was adopted: if a section contained any relevant information, it was marked as 'filled'; otherwise, it was recorded as 'unfilled'. Overall completeness was not calculated as a composite score but evaluated based on section-by-section documentation rates.

Patient demographic information (age, gender), admission shift (in-hours/out-hours), and forensic examination report details were obtained from hospital records. Patients admitted between 08:00 and 17:00 were classified as 'in-hours', and those admitted outside this timeframe were classified as 'out-hours'. Additionally, the completion rates of forensic report sections were compared between these two groups**.**

Data Collection

Patients admitted to the ED for forensic reasons were identified through the hospital's electronic database between May 1st and August 1st, 2019. The forensic examination reports for these patients were retrieved from hospital archives, and relevant data were transferred into study-specific data collection forms. The information on whether each of the fields to be filled in the emergency department forensic examination form was filled or not was recorded separately on the study forms.

Statistical analysis

Continuous data were presented as median and interquartile range (IQR: 25%-75%), while categorical data were expressed as frequencies and percentages. Continuous variables were compared using the Mann-Whitney U test. Associations between categorical variables were assessed using the Chi-square test or Fisher's Exact test, as appropriate. Statistical analyses were performed using SPSS version 23 (SPSS Inc., Chicago, IL, USA). A p-value less than 0.05 was considered statistically significant.

Ethical Approval

This study approval was obtained from the University of Health Sciences, Faculty of Medicine, SamsunTraining and Research Hospital Ethics Committee (approval ID: 53-2019 BADK/11-86, dated: 28 May 2019). This study was conducted retrospectively. Therefore, no consent form was obtained. All procedures were carried out in accordance with the Declaration of Helsinki.

Results

A total of 311 patients were included in the study. The median age was 32 years (IQR: 22-44), and 26.7% (n=83) were female. Of these admissions, 53.7% (n=167) occurred during in-hours, while 46.3% (n=144) occurred during out-hours.

The most frequently completed sections in forensic examination reports were lesion findings (95.2%; n=296), system examinations (88.7%; n=276), complaints (80.7%; n=251), performed tests (76.2%; n=237), and alcohol examination (72.3%; n=225). Sections filled at intermediate rates included past medical history (64.6%; n=201), life-threat information (59.8%; n=186), psychiatric examination (48.9%; n=152), and body diagrams (43.7%; n=136). The lowest completion rates were observed in the suitability of examination environment (3.5%; n=14), treatment notes (1.9%; n=6), and recording treatment details (1.9%; n=6).

The majority of patients (96.8%; n=301) were discharged, while 2.6% (n=8) were hospitalized in wards and 0.6% (n=2) in intensive care units. General statistics of the patients included in study shown in **Table 1.**

Table 1.General statistics

Parameters	**Median (IQR 25-75%), % (n)**
Age (Years)	32 (22-44)
Gender (Female)	26.7 (83)
Admission Shift (In-hours) (Out-hours)	53.7(167) 46.3(144)
Is the suitablity of environment for the examination filled out? (Yes)	3.5 (14)
Is the person who present during the examination recorded? (Yes)	3.2 (10)
Is the anamnesis filled out? (Yes)	26.0 (81)
Is the complaint filled out? (Yes)	80.4 (250)

Is the past medical history section filled out? (Yes)	64.6 (201)
Is the lesion findings filled out? (Yes)	95.2 (296)
Is the system examinations filled out? (Yes)	88.7 (276)
Is the psychiatric examination filled out? (Yes)	48.9 (152)
Is the section on tests performed filled out? (Yes)	76.8 (239)
Is there a body diagram? (Yes)	43.7 (136)
Is this a definitive report? (Yes)	71.4 (222)
Can the condition be eliminated by simple medical intervention? (Filled)	44.7 (139)
Is the alcohol examination filled out? (Yes)	72.3 (225)
Is the life-threat information filled in? (Yes)	59.8 (186)
Are the treatments noted? (Yes)	1.9 (6)
Hospitalization status (Externed) (Wards) (Intensive Care)	96.8 (301) 2.6 (8) 0.6 (2)

Abbeviations: Continuous data are presented as median (IQR 25%-75%). Categorical data are presented as % (n).

The distribution of case types revealed that the most common were assault (48.2%; n=150), detention examination (18.6%; n=58), and traffic accidents (16.4%; n=51). Other case types included poisoning (4.2%; n=13), work accidents (2.9%; n=9), drowning (1.9%; n=6), falls (1.6%; n=5), sharp-penetrating instrument injuries (1.3%; n=4), suicide attempts (1.0%; n=3), burns (1.0%; n=3), and firearm injuries (0.6%; n=2). Distribution of case types are shown in **Table 2**.

Table 2. Case types

Case Type	**%(n)**
Assault	48.2 (150)
Detention examination	18.6 (58)
Traffic accident	16.4 (51)
Work accident	2.9 (9)
Poisoning	4.2 (13)
Drowning	1.9 (6)
Falling	1.6 (5)
Sharp-penetrating instrument injury	1.3 (4)
Suicide	1.0 (3)
Burns	1.0 (3)
Firearm injury	0.6 (2)
Total	100 (311)

Comparing in-hours (n=167) versus out-hours (n=144) admissions, the median age was significantly higher during in-hours admissions (34 vs. 30 years; p=0.039). Out-hour admissions showed significantly higher completion rates for the suitability of examination environment (8.3% vs. 1.2%; p=0.002), complaint section (87.5% vs. 74.3%; p=0.003), past medical history section (71.5% vs. 58.7%; p=0.018), psychiatric examination (55.6% vs. 43.1%; p=0.029), performed tests (86.1% vs. 68.9%; p=0.001), body diagram (52.8% vs. 35.9%; p=0.003), and noting the possibility of simple medical intervention (52.1% vs. 38.3%; p=0.015). Other parameters did not differ significantly between shifts. Comparison between shift groups are shown in **Table 3**.

Table 3. Comparison between shift groups

Parameter	**In-Hours** (n=167)	**Out-Hours** (n=144)	**p**
Age (Years)	34 (24-47)	30 (21-41)	0.039
Gender (Female)	27.5 (46)	25.7 (37)	0.713
Is the suitablity of environment for the examination filled out? (Yes)	1.2 (2)	8.3 (12)	0.002

Is the person who present during the examination recorded? (Yes)	2.4 (4)	4.2 (6)	0.377
Is the anamnesis filled out? (Yes)	24.6 (41)	27.8 (40)	0.518
Is the complaint filled out? (Yes)	74.3 (124)	87.5 (126)	0.003
Is the past medical history section filled out? (Yes)	58.7 (98)	71.5 (103)	0.018
Is the lesion findings filled out? (Yes)	94.6 (158)	95.8 (138)	0.616
Is the system examinations filled out? (Yes)	87.4 (146)	90.3 (130)	0.427
Is the psychiatric examination filled out? (Yes)	43.1 (72)	55.6 (80)	0.029
Is the section on tests performed filled out? (Yes)	68.9 (115)	86.1 (124)	0.001
Is there a body diagram? (Yes)	35.9 (60)	52.8 (78)	0.003
Is this a definitive report? (Yes)	70.1 (117)	72.9 (105)	0.578
Can the condition be eliminated by simple medical intervention? (Filled)	38.3 (64)	52.1 (75)	0.015
Is the alcohol examination filled out? (Yes)	70.1 (117)	75.0 (108)	0.331
Is the life-threat information filled in? (Yes)	56.3 (94)	63.9 (92)	0.173
Are the treatments noted? (Yes)	1.8 (3)	2.1 (3)	0.854

Abbreviations: Continuous data are presented as median (IQR 25%-75%). Categorical data are presented as % (n). Mann Whitney U test was used to compare continuous data. Chi Square test and Fisher Exact test was used to compare categorical data. * shows Fisher Exact test result.

When comparing patients with life-threatening conditions (n=22) to those without life-threatening conditions (n=289), several significant differences were observed. Patients with life-threatening conditions had a significantly higher proportion of females (50.0% vs. 24.9%; p=0.010). Additionally, reports of patients without life-threatening conditions had significantly higher completion rates for the past medical history section (67.1% vs. 31.8%; p=0.001) and psychiatric examination (50.5% vs. 27.3%; p=0.035). In contrast, the section indicating whether the condition could be eliminated by simple medical intervention was filled significantly more often in patients with life-threatening conditions (68.2% vs. 42.9%; p=0.022).

There were no statistically significant differences between groups in age, environmental suitability for examination, anamnesis, complaints, lesion findings, system examinations, performed tests, body diagrams, alcohol examinations, definitive reporting, or noting of treatments. Shift distribution also showed no significant difference between life-threat groups. Comparison between life-threat groups are shown in **Table 4**.

Table 4. Comparison between life-threat groups

Parameter	**Life Threat: Yes** (n=22)	**Life Threat: No** (n=289)	p
Age (Years)	41.00 (19.50-58.25)	32.00 (22.00-43.00)	0.313
Gender (Female)	50 (11)	24.9 (72)	0.010
Is the suitablity of environment for the examination filled out? (Yes)	4.5 (1)	4.5 (13)	*0.650
Is the person who present during the examination recorded? (Yes)	0 (0)	3.5 (10)	-
Is the anamnesis filled out? (Yes)	22.7 (5)	26.3 (76)	0.713
Is the complaint filled out? (Yes)	68.2 (15)	81.3 (235)	0.135
Is the past medical history section filled out? (Yes)	31.8 (7)	67.1 (194)	0.001
Is the lesion findings filled out? (Yes)	95.5 (21)	95.2 (275)	0.950
Is the system examinations filled out? (Yes)	90.9 (20)	88.6 (256)	*0.539
Is the psychiatric examination filled out? (Yes)	27.3 (6)	50.5 (146)	0.035
Is the section on tests performed filled out? (Yes)	63.6 (14)	77.9 (224)	0.127
Is there a body diagram? (Yes)	54.5 (12)	42.9 (129)	0.289
Is this a definitive report? (Yes)	4.5 (1)	4.5 (13)	0.992
Can the condition be eliminated by simple medical intervention? (Filled)	68.2 (15)	42.9 (124)	0.022
Is the alcohol examination filled out? (Yes)	81.8 (18)	71.6 (207)	0.303
Are the treatments noted? (Yes)	4.5 (1)	1.7 (5)	*0.358

Shift group (in-hours)	59.1 (13)	53.3 (154)	0.599

Abbeviations: Continuous data are presented as median (IQR 25%-75%). Categorical data are presented as % (n). Mann Whitney U test was used to compare continuous data. Chi Square test and Fisher Exact test was used to compare categorical data. * shows Fisher Exact test result.

Discussion

In this study, forensic reports issued at an ED of a secondary-level state hospital were analyzed comprehensively, and the completeness rates of these reports were evaluated across different sections. According to our findings, the sections filled most completely in the forensic reports were patient identity information (100%), examination date (100%), injury findings (95.2%), and patient history (78.5%). The high rates of completion for identity and examination dates are consistent with previous studies. Yemenici et al. (10) and Çetin et al. (11) similarly reported that patient identity information and examination dates were frequently completed at high rates. However, the 95.2% completion rate for injury descriptions observed in our study represents a significant and positive difference compared to the existing literature. Aktas et al. (5) noted that injury descriptions were missing in 62.4% of reports, while Yemenici et al. (10) reported frequent inadequacies in documenting injuries. Therefore, the high completion rate for injury findings in our study indicates that physicians at this facility are particularly attentive to trauma documentation, representing an encouraging and original finding.

On the other hand, some sections had notably lower completion rates. Specifically, consultation notes (31.5%) and diagnostic test results (48.5%) were less frequently documented. Similar deficiencies have been frequently reported in the literature; Çetin et al. (11) found that consultation notes were often incomplete, and Yemenici et al. (10) noted that test results were frequently undocumented. The absence or inadequacy of these sections may lead to significant issues in forensic evaluations, particularly when specialist opinions or additional investigations are needed. Thus, it is crucial to emphasize the necessity for more diligent documentation in these specific areas of forensic reports.

In this study, the most common reasons for forensic presentations were traffic accidents, assault-related injuries, and occupational injuries, respectively. These findings align with the literature. Aktas et al. (5) reported traffic accidents (43.4%) as the most frequent reason for forensic admission, followed by assault cases. Similarly, Alpaslan and Baykan (6) demonstrated that traffic accidents and assaults constitute the largest proportions of forensic presentations. This consistency highlights that traffic accidents and violence-related injuries consistently occupy the top positions among forensic cases in Türkiye, indicating the need for stronger preventive measures for road safety and violence reduction. Additionally, the significant proportion of assault-related forensic examinations conducted in emergency departments contributes to increased patient congestion and workload. In pediatric populations, one of the most frequent medicolegal issues is neglect, which may result in fatal events such as falls or foreign body aspiration (12). Thus, conducting routine forensic examinations in separate specialized forensic units outside ED could reduce the burden on emergency healthcare providers and enhance efficiency (6).

Comparing the completeness of reports between in-hours and out-of-hours shifts, our study revealed that reports filled during out-of-hours shifts were notably more detailed and complete, particularly in patient history (83.7%), physical examination (96.1%), and life-threatening condition assessments (87.6%). This finding contrasts with much of the literature. Lai et al. (4) reported lower documentation quality during night shifts and off-hours. The higher completion rates observed in our study during out-of-hours shifts may be attributed to lower patient volumes during night shifts in less crowded centers like Sinop, providing physicians with more time for documentation. One possible explanation could be that physicians working during night shifts, regardless of experience level, may have more available time and fewer competing clinical demands, allowing for more detailed documentation. However, this interpretation remains speculative, as physician characteristics were not directly assessed in this study. Indeed, it has been noted in the literature that senior and experienced physicians often tend to provide shorter and less comprehensive documentation due to heavy clinical responsibilities (4).

Additionally, our study found that patient history documentation was significantly better in cases without life-threatening conditions (84.4%) compared to cases with life-threatening conditions (62.5%). This finding contradicts general expectations and some previous literature. Çelik et al. (13) indicated that documentation is usually more thorough in patients with life-threatening injuries. A plausible explanation for our finding could be that physicians prioritize urgent medical intervention over comprehensive documentation when managing critically ill or injured patients. Nevertheless, accurate documentation of life-threatening conditions remains crucial from a legal perspective according to Article 87 of the Turkish Penal Code (8), underscoring the necessity for consistent and complete documentation, even in critical emergency scenarios.

The frequent issuance of "preliminary forensic reports" is another significant issue identified in our study. Previous studies by Keten et al. (14) and Yemenici et al. (10) have similarly criticized the excessive use of preliminary reports,

emphasizing that this practice unnecessarily prolongs legal procedures. Therefore, it is essential to provide training and support to emergency physicians to encourage the issuance of definitive reports whenever possible.

In-service training of physicians is known to improve service quality in various fields. A study conducted with family physicians showed that cardiopulmonary resuscitation training had a positive effect on physicians' knowledge and knowledge level (15). To improve the quality of forensic reports, literature frequently emphasizes the importance of specialized training programs and establishing dedicated forensic units. Alabdulqader et al. (7) indicated a general lack of forensic documentation training among physicians, while Chaudhary et al. (16) demonstrated significant improvements in documentation quality through the establishment of Clinical Forensic Medicine Units. Adopting similar approaches in Türkiye could substantially enhance the quality of forensic reports.

Study limitations

The present study has several limitations. Its retrospective nature may have led to incomplete or incorrect data entries. Additionally, it was conducted in a single center, limiting its generalizability to other healthcare facilities. Moreover, we did not have access to information about the experience, seniority, or specific training of the physicians who prepared the forensic reports, restricting our analysis regarding the impact of these factors on report quality. Future studies employing prospective, multi-center designs and larger sample sizes may help overcome these limitations.

Conclusion

This study revealed that forensic reports had notably high documentation rates for injury descriptions but significant deficiencies in documenting consultation notes and test results. Reports prepared during out-of-hours shifts were more detailed, indicating that work shifts influence documentation quality. Additionally, incomplete documentation in critically ill or injured patients highlights the need for greater emphasis on thorough forensic documentation, even during emergency medical interventions.

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Author Contributions: *Concept: ES, MCD Literature Review: EC, MCD Design: ES, MCD. Data acquisition: ES, MCD. Analysis and interpretation: ES, MCD. Writing manuscript: ES, MCD. Critical revision of manuscript: ES, MCD.*

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References

1. Cetin S, Dalgic S. Medico-legal evaluation of deficiencies in the definition of wound depth in forensic reports: a retrospective study. Eur Rev Med Pharmacol Sci. 2024;28(9):3297-302.
2. Smith JD, Lemay K, Lee S, et al. Medico-legal issues related to emergency physicians' documentation in Canadian emergency departments. CJEM. 2023;25(9):768-75.
3. Serinken M, Türkçüer İ, Acar K, et al. Evaluation of medicolegal reports written by physicians in the emergency unit with regard to deficiencies and mistakes. Turk J Trauma Emerg Surg. 2011;17(1):23-8.
4. Lai FW, Kant JA, Dombagolla MH, et al. Variables associated with completeness of medical record documentation in the emergency department. Emerg Med Australas. 2019;31(4):632-8.
5. Aktas N, Gulacti U, Lok U, et al. Characteristics of the traumatic forensic cases admitted to emergency department and errors in the forensic report writing. Bull Emerg Trauma. 2018;6(1):64-70.
6. Alpaslan M, Baykan N. Acil serviste adli olarak değerlendirilen hastaların analizi ile darp ve cebir muayenelerinin acil servis üzerindeki yükü. Yeni Yüzyıl J Med Sci. 2025;6(1):9-16.
7. Alabdulqader S, Alabdulqader R, Madadin M, et al. Emergency physicians' awareness of medico-legal case management: a cross-sectional study from Saudi Arabia. Saudi J Med Med Sci. 2023;11(1):60-6.
8. T.C. Adalet Bakanlığı. Türk Ceza Kanunu (Kanun No: 5237) [Internet]. 2004 [cited 2025 Apr 30]. Available from: https://www.mevzuat.gov.tr/mevzuatmetin/1.5.5237.pdf
9. T.C. Adalet Bakanlığı. Tababet ve Şuabatı San'atlarının Tarzı İcrasına Dair Kanun (Kanun No: 1219) [Internet]. 1928

[cited 2025 Apr 30]. Available from: https://www.mevzuat.gov.tr/mevzuatmetin/1.3.1219-20141119.pdf
10. Yemenici S, Sayhan MB, Salt Ö, et al. Acil serviste düzenlenen adli raporların değerlendirilmesi. Harran Univ Med J. 2017;14(3):179-86.
11. Erdoğan Çetin Z, Teyin A, Birben B, et al. Evaluation of judicial reports prepared in the emergency department. Bozok Med J. 2018;8(4):34-40.
12. Şengüldür E. A case of pediatric foreign body aspiration: case report and literature review. Int J Curr Med Biol Sci. 2022;2(1):73-7.
13. Çelik Y, Karbeyaz K, Kılıboz T, et al. Adli raporların yaşamsal tehlike kriteri açısından değerlendirilmesi. Osmangazi Med J. 2021;43(4):308-17.
14. Keten A, İçme F. Acil serviste düzenlenen adli raporların Türk Ceza Kanunu kapsamında değerlendirilmesi. Turk Med J. 2011;5(3):94-9.
15. Baydın A, Duran L, Şengüldür E. Evaluation of usefulness of cardiopulmonary resuscitation education on public health physicians. J Clin Exp Invest. 2017;8(4):110-3.
16. Chaudhary B, Shukla PK, Bastia BK. Role of clinical forensic medicine unit in quality and standardization of medico-legal reports. J Forensic Leg Med. 2020; 74:102007. education for healthcare systems improvement. BMC Med Educ. 2023;23(1):207.

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Original Article

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Effect of Laboratory Confirmation of Synthetic Cannabinoid Use on Emergency Department Management and Outcomes

Sentetik Kannabinoid Kullanımının Laboratuvar Tanısının Acil Servis Yönetimi ve Sonuçları Üzerindeki Etkisi

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Abstract

Background: Synthetic cannabinoids (SCs) are a structurally diverse class of synthetic substances frequently misused as recreational drugs. The aim of this study is to evaluate the impact of laboratory-confirmed SC use on the treatment process, length of stay in the emergency department (ED), and patient prognosis in individuals presenting to the ED with a reported history of SC use.

Materials and Methods: This prospective observational study included ED patients aged 18–75 years with self-reported synthetic cannabinoid use. All enrolled patients underwent routine laboratory testing, and synthetic cannabinoid screening was performed universally using urine samples analyzed via enzyme immunoassay. SC-positive and SC-negative patients were compared in terms of lab findings, treatment, ED stay, and prognosis.

Results: The study included 101 patients (95% male, mean age 25.8 years). Most presented with symptoms (55.4%) or for addiction treatment (44.6%), commonly reporting fatigue, nausea, agitation, and palpitations. SC was detected in 6.9% of urine samples. No significant lab differences were found between SC-positive and negative patients, except for slightly lower SpO_2 levels in SC-positives. ED stay duration and patient outcomes were similar across groups, with 97% discharged and 3% monitored in the ICU.

Conclusions: The laboratory diagnosis of synthetic cannabinoids in patients presenting to the ED did not significantly affect treatment outcomes, ED length of stay, or prognosis.

Keywords: Synthetic Cannabinoid, Emergency Medicine, Substance-Related Disorders, Diagnosis, Laboratory, Prognosis

ÖZ

Amaç: Sentetik kannabinoidler (SC'ler), yapısal olarak çeşitli sentetik maddelerden oluşan ve sıklıkla eğlence amaçlı kötüye kullanılan bir madde grubudur. Bu çalışmanın amacı, acil servise (AS) SC kullanımı öyküsüyle başvuran bireylerde, laboratuvarla doğrulanmış SC kullanımının tedavi süreci, acil serviste kalış süresi ve hasta prognozu üzerindeki etkisini değerlendirmektir.

Gereç ve Yöntem: Bu prospektif gözlemsel çalışmaya, SC kullanımı bildiren ve yaşları 18–75 arasında olan AS hastaları dahil edilmiştir. Çalışmaya katılan tüm hastalara rutin laboratuvar testleri ve enzim immünoassay ile analiz edilen idrar örneklerinden sentetik kannabinoid taraması yapılmış olup; SC-pozitif ve SC-negatif hastalar, laboratuvar bulguları, tedavi süreci, AS kalış süresi ve prognoz açısından karşılaştırılmıştır.

Bulgular: Çalışmaya 101 hasta dahil edilmiştir (hastaların %95'i erkek, yaş ortalaması 25,8 yıl). Hastaların çoğu semptom (%55,4) ya da bağımlılık tedavisi talebi (%44,6) ile başvurmuş; en sık bildirilen şikayetler yorgunluk, bulantı, ajitasyon ve çarpıntı olmuştur. İdrar örneklerinin %6,9'unda SC saptanmıştır. SC-pozitif ve negatif hastalar arasında laboratuvar parametrelerinde anlamlı fark bulunmazken, SC-pozitif grupta SpO_2 düzeyleri istatistiksel olarak daha düşük bulunmuştur. AS kalış süresi ve hasta prognozu gruplar arasında benzer olup; hastaların %97'si taburcu edilmiş, %3'ü yoğun bakım izlemi gerektirmiştir.

Sonuç: AS'e başvuran hastalarda sentetik kannabinoidlerin laboratuvar tanısının, tedavi sonuçları, AS kalış süresi veya prognoz üzerinde anlamlı bir etkisi bulunmamıştır.

Anahtar kelimeler: Sentetik Kannabinoid, Acil Tıp, Madde Bağımlılığı, Laboratuvar, Prognoz

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Highlights

- This study investigated the clinical significance of laboratory-confirmed synthetic cannabinoid (SC) use in the emergency department and found that only 6.9% of self-reported SC users had laboratory-confirmed positivity, highlighting limitations in current diagnostic testing.
- No significant differences in clinical management, emergency department length of stay, or outcomes were found between SC-positive and SC-negative patients.
- Results support symptom-based clinical decision-making over laboratory confirmation for SC intoxication management in emergency settings.

Introduction

Synthetic cannabinoids (SCs) are a structurally diverse group of novel psychoactive substances (NPS) designed to target the endocannabinoid system. These substances exhibit higher affinity for cannabinoid receptors (CBRs) compared to Δ9-tetrahydrocannabinol (Δ9-THC), the primary psychoactive compound in the cannabis plant (1, 2). As a result, they induce effects similar to those of Δ9-THC but are often more intense and shorter in duration (3).

The first SC, a synthetic version of Δ9-THC, was developed in 1964 by Gaoni and Mechoulam (4). Subsequent SCs were synthesized during research aimed at understanding the regulatory roles of the endocannabinoid system in critical biological processes, culminating in the discovery of CBRs in the 1980s (5).

SCs played a prominent role in the NPS market from 2009 to 2019, though the number of new SCs introduced decreased between 2014 and 2018 (6). Nonetheless, since 2008, a total of 209 different SCs have been identified in European Union member states, and together with synthetic cathinones, they accounted for approximately 60% of all NPS seizures in 2019 (7).

Hospital presentations of individuals using SCs are often due to life-threatening conditions, with acute complications frequently affecting the cardiovascular, central nervous, and respiratory systems (8, 9). Common symptoms leading to hospital visits include altered consciousness, agitation, seizures, hypertension, or hypotension. However, the rapidly evolving chemical structures of SCs present significant challenges in diagnosing and managing these cases. The complexity of such presentations in emergency departments necessitates prompt interventions and a multidisciplinary approach. Due to their high lipophilicity and rapid hepatic metabolism, synthetic cannabinoids exhibit short plasma half-lives, often between 1 to 6 hours, and are typically detectable in urine for no more than 72 hours after use, which complicates timely laboratory confirmation of exposure (10).

This study aims to investigate the impact of laboratory confirmation of synthetic cannabinoid (SC) use on treatment processes, length of stay in the emergency department, and prognosis in patients presenting with a history of SC use.

Material and Methods

Study design

This study was conducted in the Emergency Medicine and Toxicology Clinic of a Tertiary Care Training and Research Hospital. Patients aged 18–75 years who presented with self-reported use of synthetic cannabinoids (SCs) were included in the study. Sociodemographic characteristics of the participants were analyzed using a structured data collection form.

Laboratory evaluations, including complete blood cell count, biochemistry, coagulation tests, troponin levels, and blood gas analyses, were performed for all patients. Additionally, SC levels in urine and blood samples were analyzed. Patients under the age of 18 (n=5) and those who refused to participate in the study (n=7) were excluded. A total of 101 patients were included in the study. All patients gave and signed informed consent **(Figure 1).**

Patients were also asked to report the time elapsed since their last synthetic cannabinoid use.

SC levels were determined using the enzyme immunoassay method (Immunoanalytical K2 enzyme immunoassay) on an Olympus AU 400 device. This testing was conducted on urine samples from all 101 participants, regardless of presenting symptoms or clinical suspicion, ensuring a consistent diagnostic approach across the cohort. The assay was capable of detecting JWH-018, JWH-073, and AM-2201 metabolites with a positive threshold value of 20 ng/ml. Results were reported as either positive or negative based on this cutoff. Urine samples were sent to the laboratory immediately after collection for SC level analysis.

Statistical analysis

The statistical analysis of the data was performed using SPSS (Statistical Package for the Social Sciences) version 16 software. The normality of data distribution was assessed using Kolmogorov-Smirnov and Shapiro-Wilk tests. Descriptive statistics were presented as means and standard deviations.

For comparisons of mean differences between two groups, Student's t-test was used if parametric assumptions were met, while the Mann-Whitney U test was applied if these assumptions were not met. The chi-square test or Fisher's exact test (when appropriate) was used for categorical variables. The relationships between continuous variables were evaluated using Pearson's correlation test. A p-value of <0.05 was considered statistically significant.

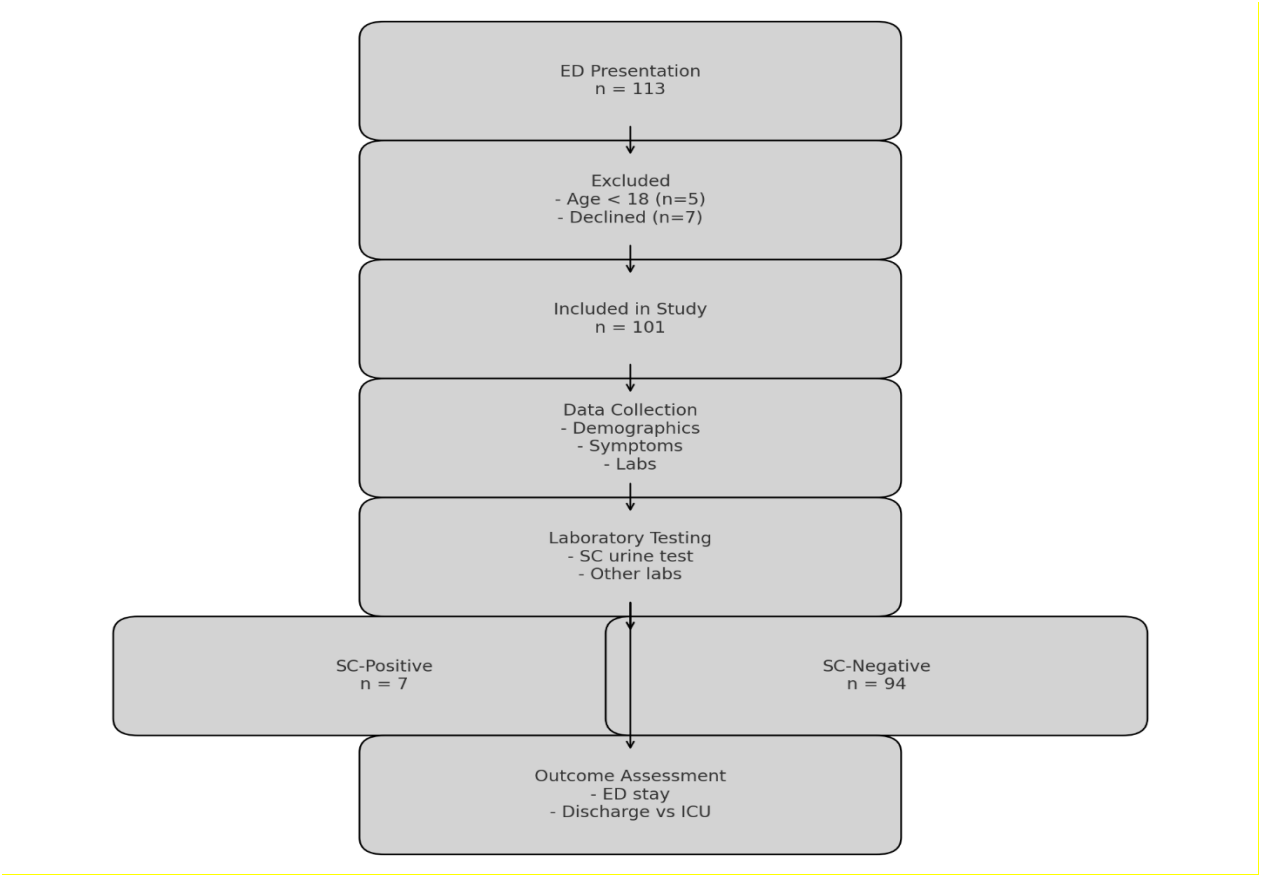

Figure 1. Study Flow Chart

Ethical Approval

This study was conducted in accordance with the Declaration of Helsinki and institutional ethical guidelines. The study approved by the Bakirkoy Dr. Sadi Konuk Training and Research Hospital's Local Ethical Board (number: IRB2015.119, date: 15.06.2015). All participants provided written informed consent prior to data collection, and their confidentiality was strictly maintained throughout the study. Data was anonymized, and access was restricted to authorized personnel only to ensure compliance with ethical standards.

Results

A total of 101 patients were included in the study, 95% of whom were male (n=96), with a mean age of 25.77±6.61 years (min: 18, max: 49). Among the patients, 48.5% (n=49) were unemployed, and only 3% (n=3) had a university degree. Additionally, 71.3% were single, and 48.5% reported having no source of income.

The primary reasons for emergency department (ED) visits were symptoms in 55.4% (n=56) of patients and seeking treatment for addiction in 44.6% (n=45). The most frequently reported symptoms included fatigue (18.8%, n=19), nausea and vomiting (17.8%, n=18), agitation (13.9%, n=14), and palpitations (6.9%, n=7). A notable 22.8% (n=23) of patients presented with no complaints **(Table 1)**.

Table 1. Presenting Complaints of Patients in the Emergency Department

Presenting Complaint	Count (n)	Percentage (%)
No Complaints	23	22.8
Fatigue	19	18.8
Agitation	14	13.9
Palpitations	7	6.9
Headache	3	3.0
Chest Pain	3	3.0
Convulsions	4	4.0
Burning Sensation on Skin	1	1.0
Nausea and Vomiting	18	17.8
Abdominal Pain	2	2.0
Syncope	4	4.0
Fear of Death	3	3.0
Dizziness	2	2.0
Seizures	2	2.0
Altered Consciousness	4	4.0
Hallucinations	2	2.0
Body Pain	1	1.0
Shortness of Breath	1	1.0

Among the 101 respondents, the median self-reported time since last use was 6 hours (range: 1–168 hours). Urine samples from patients who reported SC use revealed SC positivity in only 6.9% (n=7) of cases. No significant differences were observed in Glasgow Coma Scale (GCS) scores between SC-positive and SC-negative patients (p=0.950). Among the patients, 5.9% (n=6) had hypertension (systolic blood pressure >140 mmHg), 2% (n=2) had hypotension (systolic blood pressure <90 mmHg), and 13.9% (n=14) showed tachycardia. The fingertip oxygen saturation (SpO_2) levels were significantly lower in SC-positive patients (95.6±2.4%) compared to SC-negative patients (97.3±1.7%) (p=0.011) **(Table 2)**.

No statistically significant differences were found between SC-positive and SC-negative patients in terms of blood gas parameters (pH, pCO_2, lactate, HCO_3), complete blood count (WBC, HGB, HCT, PLT), biochemical parameters (urea, creatinine, CK, AST, ALT, LDH, amylase), coagulation parameters (INR, PT, aPTT), and electrolytes (sodium, potassium, calcium) (p>0.05). However, lipase levels were significantly higher in SC-positive patients (43.1 ± 67.6) compared to SC-negative patients (26.2±14.1) (p=0.031) **(Table 3).**

Electrocardiographic (ECG) evaluations revealed normal sinus rhythm in 69.3% (n=70) of patients, sinus tachycardia in 11.8% (n=12), and sinus bradycardia in 5.9% (n=6).

Substance use history revealed that 50.5% of patients reported alcohol use, and 96% reported tobacco use.

The average length of stay in the ED was 237.9±172.1 minutes (min: 49, max: 1140), with no statistically significant difference between SC-positive and SC-negative patients (p=0.96). Among the patients, 97% (n=98) were discharged from the ED, while 3% (n=3) required monitoring in the intensive care unit. None of the patients required inpatient ward admission.

Table 2. Patient distribution based on diagnoses.

Vital Parameters	Total	SC Negative	SC Positive	p
Systolic Blood Pressure (mmHg)	119.4 ± 14.1	119.7 ± 14.1	115.0 ± 16.1	0.398
Diastolic Blood Pressure (mmHg)	70.3 ± 12.6	70.3 ± 12.5	69.0 ± 13.6	0.779
Heart Rate (beats/min)	82.7 ± 16.8	82.8 ± 17.1	80.7 ± 12.5	0.749
Respiratory Rate (breaths/min)	18.3 ± 2.7	18.2 ± 2.6	20.1 ± 2.7	0.063
Temperature (°C)	36.6 ± 0.3	36.6 ± 2.9	36.8 ± 3.1	0.060
Saturation (%)	97.2 ± 1.8	97.3 ± 1.6	95.5 ± 2.3	0.011

Abbreviations: SC– Synthetic Cannabinoid

Table 3. Comparison of Laboratory Parameters Between Cannabinoid-Positive and -Negative Patients

Laboratory Parameters	Total	SC Negative Group	SC Positive Group	p	95% CI (Negative Group)	95% CI (Positive Group)
pH	7.38 ± 0.06	7.39 ± 0.06	7.41 ± 0.05	0.416	7.38 – 7.40	7.37 – 7.45
pCO_2 (mmHg)	43.42 ± 7.66	43.63 ± 7.64	40.74 ± 8.11	0.339	42.09 – 45.17	34.73 – 46.75
Lactate (mmol/L)	2.15 ± 1.43	2.17 ± 1.43	1.99 ± 1.57	0.751	1.88 – 2.46	0.83 – 3.15
HCO_3 (mmol/L)	24.40 ± 2.47	24.44 ± 2.51	24.01 ± 2.04	0.664	23.93 – 24.95	22.50 – 25.52
WBC ($10^3/mm^3$)	11.23 ± 3.60	11.14 ± 3.55	12.49 ± 4.28	0.344	10.42 – 11.86	9.32 – 15.66
HGB (g/dL)	14.6 ± 1.09	14.58 ± 1.11	14.94 ± 0.85	0.394	14.36 – 14.80	14.31 – 15.57
HCT (%)	41.95 ± 3.19	41.91 ± 3.25	42.49 ± 2.42	0.649	41.25 – 42.57	40.70 – 44.28
PLT ($10^3/mm^3$)	242.85 ± 56.04	242.57 ± 55.11	246.71 ± 72.45	0.851	231.43 – 253.71	193.04 – 00.38
Glucose (mg/dL)	109.45 ± 28.57	107.66 ± 29.96	119.43 ± 33.77	0.322	101.60 – 113.72	94.41 – 144.45
Urea (mg/dL)	28.55 ± 9.01	28.62 ± 9.24	27.71 ± 5.47	0.8	26.75 – 30.49	23.66 – 31.76
Creatinine (mg/dL)	0.90 ± 0.31	0.91 ± 0.32	0.90 ± 0.14	0.936	0.85 – 0.97	0.80 – 1.00
AST (U/L)	28.65 ± 21.27	29.10 ± 21.95	22.71 ± 5.59	0.447	24.66 – 33.54	18.57 – 26.85
ALT (U/L)	24.28 ± 30.31	24.72 ± 31.36	18.43 ± 5.65	0.599	18.38 – 31.06	14.24 – 22.62
Amylase (U/L)	65.39 ± 35.11	64.29 ± 31.75	80.29 ± 68.16	0.247	57.87 – 70.71	29.80 – 130.78
Lipase (U/L)	27.39 ± 21.82	26.22 ± 14.04	43.14 ± 67.63	0.047*	23.38 – 29.06	6.96 – 93.24
LDH (U/L)	246.82 ± 91.73	248.73 ± 94.50	221.14 ± 31.72	0.445	229.63 – 267.83	197.64 – 244.64
Calcium (mg/dL)	9.53 ± 0.62	9.51 ± 0.63	9.94 ± 0.45	0.076	9.38 – 9.64	9.61 – 10.27
Sodium (mmol/L)	139.83 ± 2.47	139.85 ± 2.43	139.57 ± 3.21	0.774	139.36 – 140.34	137.19 – 141.95
Potassium	4.30 ± 0.40	4.31 ± 0.41	4.27 ± 0.32	0.815	4.23 – 4.39	4.03 – 4.51
INR	1.07 ± 0.12	1.08 ± 0.12	1.05 ± 0.10	0.609	1.06 – 1.10	0.98 – 1.12
PT (sec)	13.63± 1.2	13.65 ± 1.23	13.40 ± 0.96	0.596	13.40 – 13.90	12.69 – 14.11
aPTT (sec)	26.42 ± 2.93	26.49 ± 2.92	25.49 ± 3.07	0.384	25.90 – 27.08	23.22 – 27.76
Troponin (ng/mL)	0.022 ± 0.17	0.023 ± 0.18	0.006 ± 0.01	0.804	0.01 – 0.06	0.00 – 0.01
CK (U/L)	454.33 ± 1094.88	446.88 ± 1099.28	554.43 ± 1112.06	0.803	224.65 – 669.11	269.40 – 1378.26
CK-MB (U/L)	29.12 ± 12.87	29.51 ± 13.20	24.00 ± 5.54	0.277	26.84 – 32.18	19.90 – 28.10

Abbreviations: pCO_2 – Partial pressure of carbon dioxide, HCO_3 – Bicarbonate, WBC – White blood cell count, HGB – Hemoglobin, HCT – Hematocrit, PLT – Platelet count, AST – Aspartate aminotransferase, ALT – Alanine aminotransferase, LDH – Lactate dehydrogenase, INR – International normalized ratio, PT – Prothrombin time, aPTT – Activated partial thromboplastin time, CK – Creatine kinase, CK-MB – Creatine kinase myocardial band, SC – Synthetic cannabinoid, CI – Confidence interval, SC– Synthetic Cannabinoid

Discussion

This study evaluated the demographic, clinical, and laboratory characteristics of individuals presenting to the emergency department (ED) with self-reported synthetic cannabinoid (SC) use, comparing the findings with those reported in the literature. We detected positivity rate of SC usage as %6.9. The short detection window of synthetic cannabinoids, generally up to 72 hours in urine, may explain the low positivity rate despite self-reported use, especially in cases where presentation occurred after the metabolite clearance period.

The results indicated that 95% of the patients were male, with a mean age of 25.77±6.61 years. These findings are consistent with prior studies, such as those by Hu et al. (95% male, mean age 20.6±5.1) and Bozkurt et al. (94.9% male, mean age 26.1±7.1) (11, 12). In Europe, SCs are predominantly used by individuals aged 15–34, with prevalence rates ranging from 0.1% to 1.5% (3). The predominance of young adult males among SC users underscores the susceptibility of this demographic to substance use disorders.

Regarding marital status, 71.3% of the patients were single, a finding in alignment with 67.1% reported by Bozkurt et al. (11). Additionally, the majority of patients had low educational attainment, with only 3% being university graduates. This suggests that low education levels may constitute a significant risk factor for SC use. Furthermore, 48.5% of the patients were unemployed, a rate notably higher than those reported in previous studies. The interplay between low socioeconomic status and SC use may create a self-perpetuating cycle, wherein SC use impairs the capacity for employment, further exacerbating socioeconomic challenges (12).

The primary reasons for ED visits included symptomatic complaints (55.4%) and requests for addiction treatment (44.6%). The most frequently reported symptoms were fatigue (18.8%), nausea and vomiting (17.8%), and agitation (13.9%). These findings are congruent with prior reports highlighting tachycardia and altered mental status as common clinical presentations; however, the broad spectrum of symptoms remains noteworthy (13, 14). SCs, due to

their substantially greater potency compared to natural cannabis, exhibit an elevated risk for inducing severe neuropsychiatric manifestations such as delirium, agitation, and psychosis (15, 16).

A significant finding in this study was the lower oxygen saturation (SpO_2) levels in SC-positive patients (95.6 ± 2.4%) compared to SC-negative patients (97.3 ± 1.7%) (p=0.011). Although the SC-positive group had statistically lower SpO_2 levels compared to the SC-negative group (95.6% vs. 97.3%, p = 0.011), this difference is not likely to be clinically significant, as all values remained within the normal physiological range. The small reduction may reflect mild transient hypoventilation or peripheral vasoconstriction, but it did not result in clinical hypoxia or require intervention. SCs' binding to CB1R receptors may result in deleterious effects on pulmonary function, potentially leading to alveolar damage, hemorrhage, and increased incidence of acute respiratory failure through CB1R-mediated inflammation and immune cell infiltration (17). Although data on the respiratory effects of SCs are limited, these findings provide valuable insights, suggesting the need for careful evaluation of hypoxia in SC users. The elevation in lipase among SC-positive patients was modest and remained within non-diagnostic ranges for pancreatitis. While some case reports suggest SCs may affect pancreatic function, the observed increase was not clinically meaningful in our cohort and did not correlate with abdominal pain or pancreatic pathology.

Consistent with the existing literature, no significant differences were observed in laboratory parameters, including blood gas analyses, biochemical markers, hematological indices, and coagulation profiles, between SC-positive and SC-negative patients (10).

The mean ED length of stay was 237.9 ± 172.1 minutes, aligning with the durations reported in the literature (5–6 hours) (18). A positive correlation was seen between the time elapsed since SC use and ED length of stay, suggesting that patients presenting with withdrawal symptoms require more prolonged treatment than those with acute intoxication.

In terms of outcomes, 97% of patients were discharged from the ED, while 3% required intensive care unit monitoring. No fatalities were observed. Although deaths related to SC use are rare, complications such as myocardial infarction, ischemic stroke, and acute kidney injury have been reported in the literature (19, 20). This underscores the importance of long-term follow-up and monitoring for potential complications in SC users. Because no specific antidote is currently available for synthetic cannabinoid intoxication, patient care hinges on optimized supportive measures; encouragingly, studies in other toxidromes have shown that well-designed adjunctive therapies alone can improve clinical outcomes (21).

Study limitations

Our study has a few important limitations. The number of patients who tested positive for synthetic cannabinoids was small, which makes it harder to draw strong conclusions from the comparisons. The relatively low detection rate of SCs may be attributed to the short detection window in urine. Although the median self-reported time since last use was 6 hours, some patients reported up to 168 hours, possibly exceeding the detectable period for many SC compounds. Furthermore, the SC test panel used in this study was limited to detecting only JWH-018, JWH-073, and AM-2201 metabolites. Given the rapid emergence of newer synthetic cannabinoid compounds, many of which fall outside the detection scope of this panel. The small number of SC-positive patients limits the study's statistical power and may have prevented the detection of meaningful differences between groups. This low detection rate may be due to the rapid breakdown of these substances in the body, delays in testing, or limitations in laboratory used.

Relying on patients to self-report their SC use also introduces the risk of inaccurate or incomplete information, especially given the unpredictable contents of these substances. As our study was conducted in a single emergency department, the findings may not generalize. Lastly, we only looked at short-term outcomes and there is lack of long-term follow-up after discharge, so we can't comment on longer-term effects. This study was conducted in a single-center ED with a predominantly male population (95%), which limits the generalizability of findings to other settings, particularly to female patients or different geographic regions. Future studies should consider broader testing methods, including more diverse patient populations, and explore long-term outcomes.

Conclusion

Laboratory-based diagnostic methods for SC use were not found to significantly impact the treatment process, ED length of stay, or prognosis in patients presenting to the ED. These findings suggest that clinical management should prioritize symptom-based evaluation over laboratory confirmation. Furthermore, there is a pressing need to develop and implement comprehensive public health strategies and awareness campaigns aimed at reducing the individual and societal burden associated with SC use.

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Abbreviations: ALT – Alanine aminotransferase, AM-2201 – Synthetic cannabinoid compound AM-2201, AST – Aspartate aminotransferase, aPTT – Activated partial thromboplastin time, CB_1R – Cannabinoid receptor type 1, CBR – Cannabinoid receptor, CK – Creatine kinase, CK-MB – Creatine kinase myocardial band, CI – Confidence interval, ED – Emergency department, ECG – Electrocardiogram, GCS – Glasgow Coma Scale, HCO_3^- – Bicarbonate, HCT – Hematocrit, HGB – Hemoglobin, INR – International normalized ratio, JWH-018 / JWH-073 – Synthetic cannabinoid compounds, LDH – Lactate dehydrogenase, NPS – Novel psychoactive substances, PLT – Platelet count, pCO_2 – Partial pressure of carbon dioxide, PT – Prothrombin time, SC – Synthetic cannabinoid, SpO_2 – Peripheral oxygen saturation, THC (Δ9-THC) – Delta-9-tetrahydrocannabinol, WBC – White blood cell count

References

1. Kemp AM, Clark MS, Dobbs T, et al. Top 10 facts you need to know about synthetic cannabinoids: not so nice spice. Am J Med. 2016; 129(3): 240–4.
2. Liu L, Wheeler SE, Venkataramanan R, et al. Newly emerging drugs of abuse and their detection methods: an ACLPS critical review. Am J Clin Pathol. 2018;149(2): 105–16.
3. Roque-Bravo R, Silva RS, Malheiro RF, et al. Synthetic cannabinoids: a pharmacological and toxicological overview. Annu Rev Pharmacol Toxicol. 2023; 63: 187–209.
4. Wainwright CL, Walsh SK. Pharmacology of non-psychoactive phytocannabinoids and their potential for treatment of cardiometabolic disease. In: Handbook of Experimental Pharmacology. Cham: Springer; 2024: 61–93.
5. Crocq MA. History of cannabis and the endocannabinoid system. Dialogues Clin Neurosci. 2020; 22(3): 223–8.
6. Choi N, Marti CN, DiNitto DM, et al. Cannabis and synthetic cannabinoid poison control center cases among adults aged 50+, 2009–2019. Clin Toxicol (Phila). 2020; 59(4): 334–2.
7. Eurosurveillance editorial team. The European Monitoring Centre for Drugs and Drug Addiction publishes the European Drug Report 2013: Trends and developments. Euro Surveill. 2013; 18(22): 20491.
8. Kourouni I, Mourad B, Khouli H, et al. Critical illness secondary to synthetic cannabinoid ingestion. JAMA Netw Open. 2020; 3(7): e208516.
9. Hasan MR, Tabassum T, Tanbir MA, et al. Synthetic cannabinoids-related cardiovascular emergencies: a review of the literature. Cureus. 2023; 15(7): e41929.
10. Kronstrand R, Roman M, Thelander G, et al. The pharmacology and toxicology of synthetic cannabinoids. Ther Adv Psychopharmacol. 2021; 11: 20451253211024329.
11. Bozkurt M, Uğurlu M, Evren C. Patterns of synthetic cannabinoid use and clinical presentation in Turkey. Dusunen Adam. 2019; 32(2): 175–82.
12. Vandrey R, Dunn KE, Fry JA, et al. A survey study to characterize use of spice products (synthetic cannabinoids). Drug Alcohol Depend. 2012; 120(1–3): 238–41.
13. Kasper AM, Ridpath A, Arnold JK, et al. Acute toxicity associated with synthetic cannabinoid use: a systematic review. Clin Toxicol (Phila). 2021; 59(7): 610–9.
14. Monte AA, Calello DP, Gerona RR, et al. Synthetic cannabinoid-associated emergencies: clinical insights and outcomes. Ann Emerg Med. 2020; 76(3): 345–52.
15. Alves VL, Gonçalves JL, Aguiar J, et al. The synthetic cannabinoids phenomenon: from structure to toxicological properties. A review. Crit Rev Toxicol. 2020; 50(5): 359–82.
16. Akram H, Mokrysz C, Curran HV. What are the psychological effects of using synthetic cannabinoids? A systematic review. J Psychopharmacol. 2019; 33(3): 271–83.
17. Alon MH, Saint-Fleur MO. Synthetic cannabinoid induced acute respiratory depression: case series and literature review. Respir Med Case Rep. 2017; 22: 137–41.
18. Hoyte CO, Jacob J, Monte AA, et al. Clinical presentations and outcomes associated with synthetic cannabinoid toxicity. JAMA. 2020; 324(5): 441–3.
19. Castaneto MS, Gorelick DA, Desrosiers NA, et al. Subacute complications associated with synthetic cannabinoids: a narrative review. Front Psychiatry. 2022; 13: 778395.
20. Devane WA, Hanus L, Mechoulam R, et al. Synthetic cannabinoid receptor agonists: a dynamic and evolving threat. Int J Drug Policy. 2023; 106: 103788.
21. Savaş AY, Gürgül S, Başol N. Effects of curcumin, sulforaphane and intralipid in the management of organophosphate toxicity. Int J Curr Med Biol Sci. 2021; 1(2): 44–9.

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3D Digital Models and Cadaver Use in Anatomy Education: An Altmetric Evaluation of Publications from 2020 to 2024

Anatomi Eğitiminde 3D Dijital Modeller ve Kadavra Kullanımı: 2020–2024 Yayınlarının Altmetrik Değerlendirmesi

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Abstract

Background: This study evaluates the academic and digital visibility of publications on 3D digital and cadaveric models in anatomy education (2020–2024) using altmetric indicators. It was hypothesized that 3D model-related studies receive higher engagement.

Materials and Methods: A descriptive literature review was conducted through the Springer Nature database, identifying 68 eligible articles based on predefined criteria. Altmetric data—including Altmetric Attention Score (AAS), Twitter/Facebook mentions, Mendeley readership—and citation counts were collected. Pearson correlation analysis assessed relationships between altmetric indicators and citations ($p < 0.05$).

Results: The keyword group "3D model AND anatomy AND teaching" yielded the most publications and highest metrics (AAS = 53, Twitter = 42, Facebook = 3, Mendeley = 1423, citations = 206). In total, 132 AAS points, 80 Twitter mentions, 9 Facebook mentions, 3365 Mendeley readers, and 712 citations were recorded. Strong positive correlations were found between AAS and Mendeley ($r = 0.999$), Twitter ($r = 0.917$), and Facebook ($r = 0.998$). AAS ($r = 0.728$) and Mendeley readership ($r = 0.748$) also showed notable correlations with citation counts.

Conclusions: 3D digital models demonstrate higher academic and digital visibility than cadaveric models. Mendeley readership appears to be a more stable predictor of scholarly impact compared to AAS. Areas such as pediatric anatomy, pathology, and real-time clinical modeling remain underexplored. Altmetric analysis provides valuable insights into the evolving tools used in anatomy education.

Keywords: 3D digital models; anatomy education; altmetric analysis; cadaver models; medical education

ÖZ

Amaç: Bu çalışma, 2020–2024 yılları arasında anatomi eğitiminde 3D dijital ve kadaverik modellerin kullanımına yönelik yayınların akademik ve dijital görünürlüğünü altmetrik göstergeler kullanarak değerlendirmeyi amaçlamaktadır. 3D model odaklı çalışmaların daha yüksek etkileşim aldığı hipoteziyle yola çıkılmıştır.

Gereç ve Yöntem: Springer Nature veritabanı kullanılarak tanımlayıcı bir literatür taraması yapılmış ve önceden belirlenmiş kriterlere göre 68 uygun makale belirlenmiştir. Altmetric Attention Score (AAS), Twitter/Facebook paylaşımları, Mendeley okuyucu sayısı ve atıf sayıları toplanmıştır. Altmetrik göstergeler ile atıf sayıları arasındaki ilişki Pearson korelasyon analizi ile değerlendirilmiştir ($p < 0.05$).

Bulgular: "3D model AND anatomy AND teaching" anahtar kelime grubu en fazla yayını ve en yüksek metrikleri üretmiştir (AAS = 53, Twitter = 42, Facebook = 3, Mendeley = 1423, atıf = 206). Tüm gruplarda toplamda 132 AAS puanı, 80 Twitter, 9 Facebook paylaşımı, 3365 Mendeley okuyucusu ve 712 atıf kaydedilmiştir. AAS ile Mendeley ($r = 0.999$), Twitter ($r = 0.917$) ve Facebook ($r = 0.998$) arasında çok güçlü pozitif korelasyonlar bulunmuştur. AAS ($r = 0.728$) ve Mendeley okuyucu sayısı ($r = 0.748$) atıf sayılarıyla da anlamlı ilişkiler göstermiştir.

Sonuç: 3D dijital modeller, kadaverik modellere kıyasla daha yüksek akademik ve dijital görünürlüğe sahiptir. Mendeley okuyuculuğu, AAS'tan daha tutarlı bir akademik etki göstergesi olarak öne çıkmıştır. Pediatrik anatomi, patoloji modellemeleri ve gerçek zamanlı klinik uygulamalar gibi alanlar daha fazla araştırmaya ihtiyaç duymaktadır. Altmetrik analiz, anatomi eğitiminde kullanılan araçların değişen yapısını anlamada önemli bilgiler sunmaktadır.

Anahtar kelimeler: 3D dijital modeller; anatomi eğitimi; altmetrik analiz; kadaver modelleri; tıp eğitimi

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Highlights Toplam 3 satır

- Anatomy education
- Altmetric evaluation
- 3D digital models

Introduction

In recent years, the measurement of scholarly impact has evolved beyond traditional citation counts. Altmetric analysis, which evaluates the online attention of scientific publications across platforms such as social media, news outlets, blogs, and reference managers like Mendeley, offers a broader view of how research disseminates and influences both academic and non-academic audiences (1). Unlike conventional bibliometrics, altmetrics provide near real-time feedback and can capture public engagement, policy influence, and interdisciplinary interest in scientific work (2).

Despite its growing use in various medical fields, the integration of altmetric analysis into anatomical education research remains limited. Most altmetric studies in medical literature focus on fields such as oncology, cardiology, or general surgery, with relatively fewer publications assessing anatomy-specific educational tools or technologies (3).

Anatomical education has traditionally relied on cadaveric dissection, which is widely regarded as a foundational and irreplaceable component in the training of health professionals. Cadaver-based education provides unique tactile, spatial, and contextual learning experiences that are difficult to replicate (4). However, increasing ethical considerations, costs, and the global shortage of cadavers have posed significant challenges for anatomy departments worldwide (5).

To address these limitations, educators and researchers have turned to innovative solutions such as three-dimensional (3D) digital modeling. These technologies offer customizable, cost-effective, and reusable models that can enhance the teaching of complex anatomical structures and procedures (6,7). Particularly in recent years, the use of 3D-printed models in anatomy education has expanded rapidly, with increasing publication output and academic interest.

Given this background, this study aims to evaluate the visibility and impact of scientific literature focusing on the use of 3D digital models and cadaveric models in anatomical education over the past five years. By analyzing Altmetric Attention Scores (AAS), citation counts, and social media mentions, we aim to map current trends and highlight the most influential contributions in this interdisciplinary and rapidly evolving domain. The primary aim of this study is to assess the online impact and scholarly visibility of publications related to 3D digital models and cadaveric models in anatomy education over the past five years through altmetric analysis. It is hypothesized that research focusing on 3D digital models in anatomical education will exhibit higher Altmetric Attention Scores and social media engagement compared to studies based on traditional cadaveric models, reflecting the increasing interest in innovative educational technologies within this field.

Material and Methods

Study Design

This study is a descriptive literature review aimed at analyzing the altmetric attention of scientific publications on three-dimensional (3D) anatomical modeling and digital models, including cadaver-based anatomical education materials. The review focuses on these publications' visibility and social impact across digital platforms, including social media, news outlets, and academic databases. The research covers publications published between January 2020 and December 2024. This study did not need to be approved by an ethics committee, because it only conducted altmetric analyses on classical studies that have been published.

Database and Search Strategy

Database selection in this study, only the Springer Nature database was utilized. The primary rationale for limiting the search to a single database was to ensure methodological consistency and data integrity. Using multiple databases can introduce heterogeneity due to variations in indexing policies, classification systems, and content coverage, which may compromise the comparability and reliability of the results. Springer Nature is a well-established platform known for its comprehensive and up-to-date scientific content, hosting high-impact journals across various disciplines. Notably, for the present study focusing on anatomical education, Springer offers a

specific filtering option under the "Anatomy" category. This feature enabled a highly specific and sensitive literature search, minimizing irrelevant results and enhancing the precision of the selection process. Therefore, the decision to rely on a single, but thematically relevant and high-quality database was made to preserve data quality and maintain methodological coherence throughout the study. To ensure methodological rigor and transparency in the selection of publications, a systematic search strategy was employed. Records were initially identified through the Springer database (n = 8369). After removing duplicates (n = 92), 8277 records remained. Subsequently, specific filtering criteria were applied, including publication date (2020–2024), article type (original, research, or review), language (English), open access status, and relevance to the selected subject areas and disciplines (e.g., 3D imaging, anatomy, education, biomechanical analysis and modeling within medicine and education). These filters reduced the pool to 68 articles. All 68 articles were screened by title and abstract, and then assessed in full-text for eligibility. Ultimately, 68 studies met all inclusion criteria and were incorporated into the final analysis (Table 1). The search strategy used Boolean operators (AND, OR) to combine relevant terms effectively. A total of 68 articles were identified across four search strategies combining 3D digital models, anatomy, education, and cadaver usage. Quantitative analysis was conducted based on Altmetric Attention Scores (AAS), social media engagement (Twitter and Facebook mentions), Mendeley readership, and citation counts. The search was limited to English-language publications, and the following keywords were employed:

- "3D digital models" AND anatomy AND cadaver
- "3D anatomical model" AND education AND cadaver
- "3D model" AND anatomy AND teaching
- "cadaver study" AND 3D digital models AND anatomy

The articles retrieved were initially screened based on their titles and abstracts to determine relevance. Studies were included if they directly involved 3D anatomical modeling in human anatomy, including cadaver studies. Only full-text articles with a valid Digital Object Identifier (DOI) and accessible through SpringerLink were **considered.**

Article Selection and Inclusion Criteria

Inclusion Criteria:

- The study directly involved 3D anatomical modeling or 3D digital models.
- The topic was clearly related to human anatomy and included cadaver studies.
- The full text was accessible via SpringerLink.
- The article had a valid Digital Object Identifier (DOI).

Exclusion Criteria:

- Studies that did not discuss 3D anatomical modeling or digital models or cadaver.
- Studies focusing on areas outside human anatomy (e.g., animal studies or material science).
- Articles not available as full text.

A total of 68 articles meeting the inclusion criteria were selected for further analysis.

Altmetric Data Collection

The Altmetric Attention Score (AAS) is a quantitative measure of the online attention an academic publication receives across various digital platforms. It is calculated based on mentions and engagement from sources such as Twitter, Facebook, news outlets, blogs, Wikipedia, YouTube, Reddit, policy documents, and Mendeley. Each source contributes differently to the score, depending on its reach and credibility; for example, a news article mention contributes more than a tweet. The AAS allows for the assessment of scholarly impact not only through traditional citations but also through public and digital engagement, making it a valuable metric particularly for studies focusing on online visibility and influence (8).

The following indicators were collected:

- **Altmetric Attention Score (AAS**): A composite score representing the online attention the article has received across various platforms.
- **Mentions on platforms:** The number of mentions on Twitter, Facebook, news outlets, and blogs.
- **Mendeley readership:** The number of readers on Mendeley, a reference manager and social network for researchers.
- **Open Access Status:** Whether the article is open access or behind a paywall.
- **Journal Name:** The journal in which the article was published.

Inclusion of Cadaver Studies

Cadaver-based anatomical education materials, particularly those integrating 3D digital model technologies, were also included in the analysis. These studies focus on digital modeling real human tissues for anatomical education.

Statistical analysis

To determine the relationships between the number of citations of the selected T100 anatomy education articles

and AAS and between IF and AAS, descriptive statistics was revealed and evaluated with SPSS 22 package software. Moreover, data were analyzed using Pearson correlation coefficient to assess the strength and direction of linear relationships between continuous variables, including Altmetric Attention Score (AAS), Twitter mentions, Facebook mentions, Mendeley readership, and citation counts. Prior to analysis, the normality of the data distributions was confirmed using the Shapiro-Wilk test. A p-value of less than 0.05 was considered statistically significant.

Ethical Approval

This study did not need to be approved by an ethics committee, because it only conducted altmetric analyses on classical studies that have been published.

Results

A total of 8369 records were initially identified through a systematic search of the Springer Nature database. Following the removal of 92 duplicate entries, 8277 unique records remained for initial evaluation. A series of filters were then applied to refine the dataset, including publication date (2020–2024), article type (original articles, research papers, or reviews), language (English), open access availability, and relevance to specific subjects (3D imaging, anatomy, education, biomechanical analysis and modeling), disciplines (medicine and education), and subdisciplines (medical education and anatomy). As a result of this filtering process, the number of records was reduced to 68 articles. These 68 records were screened by title and abstract, after which all were assessed in full-text form for eligibility. Ultimately, all 68 studies met the inclusion criteria and were included in the final analysis. The detailed selection process is illustrated in the flow diagram **(Table 1)**.

Table 1. Flow diagram of the study selection process conducted using keywords and filters

Records identified through Springer database searching
(n = 8369)
↓
Duplicates removed
(n = 92)
↓
Records after duplicates removed
(n = 8277)
↓
Records after applying filters:
- Date (2020–2024)
- Article type (Original, Research, Review)
- Open Access
- English
- Subjects: 3D imaging, anatomy, education, biomechanical analysis and modeling
- Disciplines: Medicine, Education
- Subdisciplines: Medical Education, Anatomy
- SDG: Quality Education
(n = 68)
↓
Records screened (title and abstract)
(n = 68)
↓
Full-text articles assessed for eligibility
(n = 68)
↓
Studies included in the final analysis
(n = 68)

In addition, the 68 publications included in the final analysis were categorized according to predefined keyword combinations and filtering criteria. The distribution revealed that the keyword group “3D model” AND anatomy AND teaching yielded the highest number of relevant publications (n = 37), followed by “3D anatomical model”

AND education AND cadaver (n = 15), "3D digital models" AND anatomy AND cadaver (n = 8), and "cadaver study" AND 3D digital models AND anatomy (n = 8). In terms of article types, original articles constituted the largest portion (n = 68), while research articles totaled 61, and review articles were limited to 7 publications. All included articles were in English and available through open access sources, aligning with the applied inclusion criteria. Regarding subject coverage, education (n = 41), anatomy (n = 24), and 3D imaging (n = 23) were the most frequently represented categories. Less frequently encountered topics included biomechanical analysis and modeling (n = 4). All studies were also indexed under Medical Education and Quality Education within the Springer database classification system. This distribution highlights the concentration of recent literature around educational applications of 3D models, particularly in teaching contexts, and underscores the dominant role of open-access English-language research in this domain **(Table 2) (Figure 2).**

Table 2. Numerical distribution of included publications according to keywords and filtering criteria

Filters	"3D digital models" AND anatomy AND cadaver	"3D anatomical model" AND education AND cadaver	"3D model" AND anatomy AND teaching	"cadaver study" AND 3D digital models AND anatomy	Total
Original article	8	15	37	8	68
Research article	7	13	34	7	61
Review article	1	2	3	1	7
Open access	8	15	37	8	68
English	8	15	37	8	68
3D imaging	5	5	8	5	23
Anatomy	4	7	9	4	24
Education	3	8	27	3	41
Biomechanical analysis and modeling	1	0	3	0	4
Medicine Education	8	15	37	8	68
Quality Education	8	15	37	8	68
Total	8	15	37	8	68

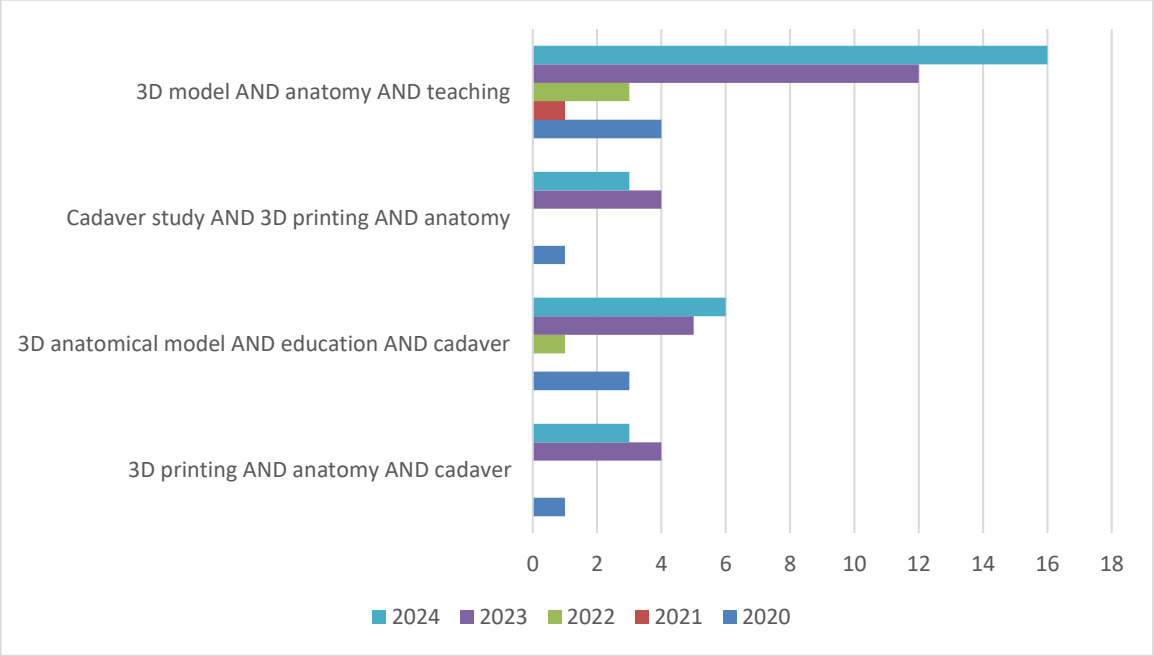

Figure 2. Distribution of publication by year

Moreover, the findings were evaluated based on quantitative indicators such as Altmetric Attention Scores (AAS), Twitter and Facebook mentions, Mendeley readers, and citation counts. These metrics aimed to reflect both the digital visibility and the academic impact of the selected publications. Below, the results are presented according to the respective keyword groupings.

Also, altmetric data were analyzed across four predefined keyword combinations to evaluate the digital visibility and academic impact of the included publications. The highest Altmetric Attention Score (AAS) was observed in the group "3D model AND anatomy AND teaching", with a score of 53, followed by "3D digital models AND anatomy AND cadaver" and "cadaver study AND 3D digital models AND anatomy", each with an AAS of 27, and "3D anatomical model AND education AND cadaver" with 25. In terms of social media engagement, the "3D model AND anatomy AND teaching" group also received the highest number of Twitter mentions (42) and Facebook mentions (3). This keyword group additionally stood out in terms of Mendeley readership, with 1423 readers, indicating strong academic interest. It was also associated with the highest citation count (206). Across all groups, a total of 132 AAS points, 80 Twitter mentions, 9 Facebook mentions, 3365 Mendeley readers, and 712 citations were recorded **(Table 3) (Figure 1).**

Table 3. Distribution of altmetric data according to keywords

Keywords	AAS	Twitter Mentions	Facebook Mentions	Mendeley Readers	Number of cites
3D digital models AND anatomy AND cadaver	27	9	2	675	183
3D anatomical model AND education AND cadaver	25	20	2	592	140
cadaver study AND 3D digital models AND anatomy	27	9	2	675	183
3D model AND anatomy AND teaching	53	42	3	1423	206
Total	132	80	9	3365	712

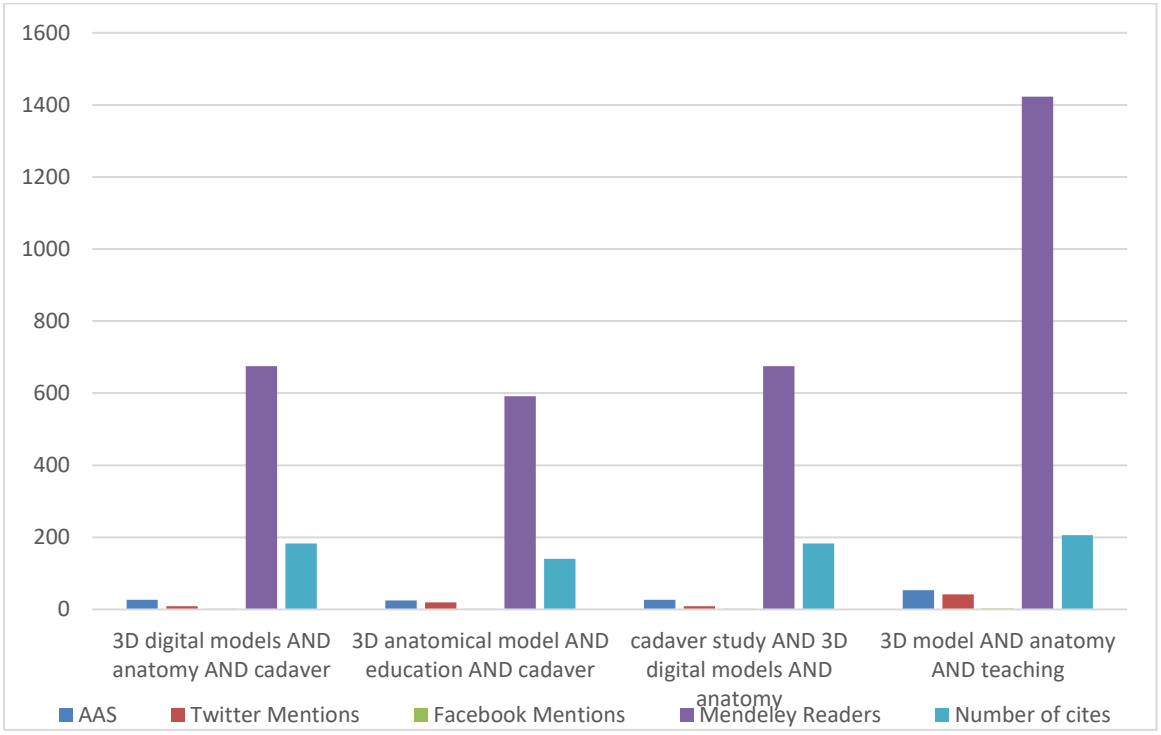

Figure 1. Distribution of twitter, facebook, and mendeley based on keywords

These findings suggest that research related to 3D models in teaching anatomy garners more online attention and academic engagement compared to studies focusing more narrowly on cadaver-based or digital models -specific contexts.

Moreover, a Pearson correlation analysis was performed to examine the relationships among Altmetric Attention Score (AAS), Twitter mentions, Facebook mentions, Mendeley readership, and citation counts. The results demonstrated very strong positive correlations between AAS and Mendeley readership (r = 0.999), as well as strong correlations between AAS and social media mentions, including Twitter (r = 0.917) and Facebook (r = 0.998). Citation counts showed moderate to high positive correlations with AAS (r = 0.728) and Mendeley readership (r = 0.748), while the correlation between Twitter mentions and citation counts was lower (r = 0.393) **(Table 4).** These findings support a significant association between digital attention metrics and traditional academic impact indicators, thereby reinforcing the relevance of altmetric data in assessing the visibility and influence of publications.

Table 4. Relationships between AAS, social media mentions, mendeley readers, and citations

Variables	Correlation Coefficient (r)
AAS - Twitter Mentions	0.917 (Very strong positive)
AAS - Facebook Mentions	0.998 (Almost perfect positive)
AAS - Mendeley Readers	0.999 (Very strong positive)
AAS - Number of cites	0.728 (Moderate to high positive)
Twitter - Facebook	0.943 (Strong positive)
Twitter - Mendeley	0.905 (Strong positive)
Twitter - Cites	0.393 (Moderate positive)
Facebook - Mendeley	0.995 (Almost perfect positive)
Facebook - Cites	0.677 (Moderate to high positive)
Mendeley - Cites	0.748 (Moderate to high positive)

Discussion

This study evaluated the academic and digital visibility of publications related to 3D-printed and cadaveric models in anatomy education over the past five years, with the hypothesis that 3D digital models focused studies would demonstrate greater scholarly and public engagement. The findings strongly support this hypothesis. A consistent rise in publication frequency was observed, particularly in 2023 and 2024 (Figure 1). This trend likely reflects the post-pandemic shift toward remote learning and the increasing integration of digital tools in medical education. Notably, publications using the keyword combination "3D digital models AND anatomy AND cadaver" peaked at 24 in 2024 the highest among all groups highlighting growing academic interest in hybrid anatomical education models that integrate technological innovation (Figure 2). Moreover, correlation analysis of this study revealed strong and statistically significant positive relationships among various altmetric indicators and traditional citation counts. Notably, the Altmetric Attention Score (AAS) showed very strong correlations with Mendeley readership (r = 0.999), Twitter mentions (r = 0.917), and Facebook mentions (r = 0.998), highlighting the close link between overall digital attention and specific social media platforms. Citation counts demonstrated moderate to high positive correlations with AAS (r = 0.728) and Mendeley readership (r = 0.748), suggesting that higher online engagement is generally associated with increased academic impact. However, the relatively lower correlation between Twitter mentions and citation counts (r = 0.393) may indicate that Twitter activity alone is a less consistent predictor of scholarly citations. These findings support the use of altmetric data as complementary indicators to traditional metrics, reflecting different dimensions of research visibility and influence in both academic and broader digital contexts, thereby strengthening the robustness of our study data.

In addition, altmetric indicators further supported this shift. While Twitter and Facebook activity remained modest overall, studies including 3D digital models keywords consistently showed higher engagement on Twitter, averaging around 10 mentions. Facebook, on the other hand, was rarely used for academic dissemination, suggesting limited utility for scholarly communication on that platform. The altmetric analysis revealed that overall social media engagement was relatively limited, particularly on Facebook. While Twitter mentions totaled 80 and Mendeley readers reached 3365, Facebook mentions remained notably low at only 9. Several factors may explain this limited presence. First, the study covers a recent five-year period (2020–2024), with a significant number of included publications concentrated in 2023 and 2024. Given this recency, it is likely that many publications have not yet had sufficient time to gain broader visibility on slower-growing platforms such as Facebook. In addition, shifting user preferences may play a role; academic communities increasingly favor platforms like Twitter for scholarly dissemination due to their immediacy and interactive nature. Facebook, in contrast, may be less commonly used for

sharing academic content in real time. Ethical considerations may also contribute studies involving cadaver-based methods or sensitive medical content are often less visible on general public platforms due to content policies or ethical reservations. Nonetheless, this study reveals that the themes highlighted in this study particularly the innovative use of 3D digital models in anatomy education will gain increasing visibility across social media in the future. The present findings may help raise awareness and contribute to greater social media dissemination in the coming years.

Mendeley readership emerged as the most reliable indicator of academic attention. Studies on 3D-printed models had substantially higher Mendeley reader counts, often exceeding 100. For example, a 2020 systematic review on 3D-printed anatomy models reached 272 readers and received 110 citations (9), while a 2023 study on pedagogical use of 3D models had 144 readers (10). Another 2024 study on immersive learning technologies in health education garnered 133 readers (11), indicating rising interest in augmented and virtual reality applications. A positive correlation was observed between Mendeley readers and citation counts, reinforcing the value of Mendeley as an early marker of scholarly impact. In contrast, cadaver-based studies generally received lower engagement across both altmetric and academic platforms. This may be attributed to logistical, ethical, and accessibility limitations that reduce their adaptability and visibility in digital and global educational settings. Several high-impact studies further illustrated this pattern. A 2021 systematic review on 3D digital models for interventional radiology training was cited 44 times (12), and a 2024 study on preoperative 3D modeling for shoulder surgery, despite being recent, already showed signs of strong academic interest (13). Similarly, studies involving virtual and augmented reality in pathology and anatomy education reported solid Mendeley readership, such as Moro et al. with 33 readers (14) and Timonen et al. with 52 readers (15). Although Twitter engagement was generally limited, papers addressing ethical debates or innovative methods gained higher Altmetric Attention Scores (AAS). For instance, a 2024 review on extended reality in surgical training reached an AAS of 10 (16), and a publication discussing the replacement of live animals in trauma simulation drew notable interest (AAS 8, 25 Mendeley readers) (17). These cases suggest that novelty, ethics, and clinical relevance may enhance both public and academic engagement. Analysis of publication venues also revealed noteworthy patterns. Journals like BMC Medical Education (60 articles) and Medical Science Educator (7 articles) led in publication count. This distribution reflects the cross-disciplinary nature of 3D digital models research, with applications spanning both educational and clinical domains. The prominence of BMC Medical Education highlights a growing emphasis on innovative teaching strategies in health sciences education. In terms of publication types, most studies were categorized as research articles (n = 49), followed by review articles (n = 7). This suggests that while the field is grounded in empirical work, there is also substantial effort to synthesize and evaluate existing literature. The relatively lower number of original studies (n = 12) points to a need for more primary, experimental research to further develop the evidence base. Despite the overall positive trends, certain subfields remained underrepresented. Topics such as pediatric anatomy, veterinary applications, pathology-based simulations, and real-time clinical 3D digital models integration were infrequently addressed. These areas offer valuable opportunities for future investigation, particularly in expanding the scope and inclusivity of anatomical education technologies.

In our analysis, the five publications with the highest altmetric scores stand out in terms of content type, recency, and digital engagement. The systematic review and meta-analysis by Ye et al. and the systematic review by Brumpt et al. provide comprehensive and up-to-date evidence regarding the effectiveness of 3D digital models in anatomy education, contributing significantly to both academic discourse and digital dissemination (9,10). Similarly, the randomized controlled trial conducted by Veer et al. explores the impact of mixed reality on interdisciplinary medical education specifically in physiology, anatomy, pathology, and pharmacology offering innovative pedagogical insights (18). Montesinos et al. present a transdisciplinary experiential learning approach within biomedical engineering education, proposing a systems-level model for healthcare training (19). Lastly, Torda introduces the CLASSIE model, which integrates virtual reality into ethical clinical decision-making, showcasing a novel method for incorporating medical ethics into medical curricula (20). These studies have garnered high visibility and sharing rates on social media platforms due to their innovative educational approaches, interdisciplinary content, and open-access publication format. This suggests that both academic value and digital accessibility play crucial roles in enhancing the online impact of educational research.

Finally, the findings demonstrate that 3D digital models have become a central focus in anatomy education, surpassing cadaver-based models in both academic and digital impact. Mendeley readership, in particular, proved a consistent and meaningful proxy for academic interest. These results not only validate the growing role of educational technologies in medical education but also highlight the need for continued innovation and exploration in this evolving field.

Study limitations

This study has several limitations. It included only publications with accessible altmetric data and valid DOIs, potentially excluding relevant research not tracked by altmetric. Moreover, open access status, indexing differences, and journal visibility may have influenced attention metrics. Therefore, while altmetrics provide useful insights, they should be interpreted alongside traditional bibliometric indicators for a more comprehensive understanding. Moreover, one notable limitation of this study is its reliance solely on the Springer Nature database for the literature review. While this approach ensured methodological consistency and enabled a highly specific search process focused on anatomical content, it may have excluded relevant studies indexed in other major databases such as PubMed, Scopus, or Web of Science. This may limit the generalizability of the findings to some extent. Future research would benefit from adopting a broader search strategy that includes multiple databases to capture a more comprehensive range of publications. This is particularly important for studies aiming to explore broader or interdisciplinary topics beyond the scope of anatomy. Expanding the database coverage could strengthen the evidence base and provide a more nuanced understanding of trends across educational or scientific domains.

Conclusion

This study provides a focused assessment of the academic and digital visibility of publications related to 3D digital models and cadaver-based methods in anatomy education from 2020 to 2024. The analysis of altmetric indicators such as Altmetric Attention Scores, social media mentions, Mendeley readership, and citation counts revealed that studies involving 3D digital models generally achieved greater scholarly impact, particularly through higher citation rates and Mendeley reader counts. Although social media engagement was modest overall, certain topics with technological or ethical relevance drew notable public interest. The observed correlation between Mendeley readership and citation counts highlights Mendeley's potential as an early indicator of academic impact. Additionally, gaps in areas such as pediatric applications and clinical use of 3D models suggest promising directions for future research. Overall, this study demonstrates the value of integrating altmetric analysis with traditional bibliometrics to capture a publication's broader influence in both academic and public domains.

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References

1. Bornmann L. Do altmetrics point to the broader impact of research? An overview of benefits and disadvantages of altmetrics. Journal of Informetrics. 2024; 8(4), 895–903.
2. Sugimoto CR, Work S, Larivière V, et al. Scholarly use of social media and altmetrics: A review of the literature. Journal of the Association for Information Science and Technology. 2017; 68(9):2037–62.
3. Kolahi J, Khazaei S, Iranmanesh M. Altmetric analysis of top 100 articles in medical education. BMC Medical Education. 2021; 21:101.
4. Estai M, Bunt S. Best teaching practices in anatomy education: A critical review. Annals of Anatomy. 2016; 208:151–7.
5. McLachlan JC, Bligh J, Bradley P, et al. Teaching anatomy without cadavers. Medical Education. 2004;38(4):418–24.
6. AbouHashem Y, Dayal M, Savanah S, et al. The application of 3D printing in anatomy education. Med Educ Online. 2015; 20:29847. doi:10.3402/meo. v20.29847.
7. Lim KH, Loo ZY, Goldie SJ, et al. Use of 3D printing in medical education: A mixed-methods survey study. BMJ Open. 2018; 8(1):e019037.
8. Zissette S, Gautam A, Krumholz HM, et al. Altmetric attention scores and citations of published research with or without preprints. JAMA Netw Open. 2024; 7(7):e2424732.
9. Ye Z, Dun A, Jiang H, et al. The role of 3D printed models in the teaching of human anatomy: a systematic review and meta-analysis. BMC Med Educ. 2020; 20(1):335.
10. Brumpt E, Bertin E, Tatu L, et al. 3D printing as a pedagogical tool for teaching normal human anatomy: a systematic review. BMC Med Educ. 2023;23(1):783.
11. Asoodar M, Janesarvatan F, Yu H, et al. Theoretical foundations and implications of augmented reality, virtual reality, and mixed reality for immersive learning in health professions education. Adv Simul (Lond). 2024; 9(1):36.

12. Tenewitz C, Le RT, Hernandez M, et al. Systematic review of three-dimensional printing for simulation training of interventional radiology trainees. 3D Print Med. 2021;7(1):10.
13. Fidanza A, Caggiari G, Di Petrillo F, et al. Three-dimensional printed models can reduce costs and surgical time for complex proximal humeral fractures: preoperative planning, patient satisfaction, and improved resident skills. J Orthop Traumatol. 2024;25(1):11.
14. Moro C, Bu D, Gadgil A, et al. Virtual models using augmented reality may provide a suitable supplement, although not a physical specimen replacement, in pathology education. Med Sci Educ. 2023;33(4):879-85.
15. Timonen T, Dietz A, Linder P, et al. The effect of virtual reality on temporal bone anatomy evaluation and performance. Eur Arch Otorhinolaryngol. 2022;279(9):4303-12.
16. Toni E, Toni E, Fereidooni M, et al. Acceptance and use of extended reality in surgical training: an umbrella review. Syst Rev. 2024;13(1):299.
17. Swain C, Stathakarou N, Alzuguren P, et al. Trauma surgical simulation: discussing the replacement of live animals used as human patient simulators. Adv Simul (Lond). 2024;9(1):7.
18. Veer V, Phelps C, Moro C. Incorporating mixed reality for knowledge retention in physiology, anatomy, pathology, and pharmacology interdisciplinary education: a randomized controlled trial. Med Sci Educ. 2022;32(6):1579-86.
19. Montesinos L, Salinas-Navarro DE, Santos-Diaz A. Transdisciplinary experiential learning in biomedical engineering education for healthcare systems improvement. BMC Med Educ. 2023;23(1):207.
20. Torda A. CLASSIE teaching - using virtual reality to incorporate medical ethics into clinical decision making. BMC Med Educ. 2020;20(1):326.

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Original Article

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Root Cause Analysis in Sharps Injuries: Fishbone Diagram

Kesici Delici Alet Yaralanmalarında Kök Neden Analizi: Balık Kılçığı Diyagramı

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Abstract

Background: During clinical practice, students are in the high-risk group for occupational needle stick/sharp piercing injuries due to limited clinical experience, inadequate attention to personal safety, and lack of knowledge.

Materials and Methods: In the first part of the qualitative study, Demographic Information Form was used to collect demographic data of the students and in the second part, fishbone diagram was used to determine the root causes of sharps injuries.

Results: The mean age of the participants was 22.30±0.702 years, 80% were female and 20% were male. Of the students, 76.7% were nursing students and 23.3% were midwifery students, and all of them were 4th year vocational education students. 46.7% of the participants practiced in internal units, 30% practiced in surgical units and 23.3% in intensive care unit. It was determined 86.7% of the participants had experienced a sharps injury once. In the root cause analysis of students' sharps injuries according to the fishbone method, four main headings were identified: healthcare workers, material, environment and method.

Conclusions: When the root causes were analyzed, it was found that all of the sharps injuries were preventable. With an effective intervention for these causes, it is expected that the material and moral damages that may be experienced will be minimized.

Keywords: Sharp objects injury, penetrating objects injury, student, root cause

ÖZ

Amaç: Klinik uygulamaları sırasında öğrenciler sınırlı klinik deneyim, kişisel güvenliğe yetersiz dikkat, bilgi eksiklikleri nedeniyle mesleki iğne batması/kesici delici alet yaralanmaları açısından yüksek riskli grupta yer almaktadırlar.

Gereç ve Yöntem: Nitel çalışmanın ilk bölümde öğrencilerin demografik verilerini Demografik Bilgi Formu ile İkinci bölümde kesici delici alet yaralanmalarının kök nedenlerinin belirlenmesi amacıyla balık kılçığı diyagramı kullanıldı.

Bulgular: Araştırmaya katılanların %80'i kadın, %20' si erkek olup yaş ortalamaları 22,30±0,702'dir. Öğrencilerin %76,7'si hemşirelik, %23,3'ü ebelik olup hepsi 4. sınıf işletmede mesleki eğitim öğrencisi idi. Katılımcıların %46,7'si dahili birimlerde, %30'u cerrahi birimlerde, %23,3'ü yoğun bakımda uygulamaya çıkmışlardı. Katılımcıların %86,7'si bir kez kesici delici alet yaralanması yaşamıştı. Öğrencilerin kesici delici alet yaralanmalarının balık kılçığı yöntemine göre yapılan kök neden analizinde; sağlık çalışanları, malzeme, ortam ve yöntem olmak üzere dört ana başlık belirlendi.

Sonuç: Elde edilen kök nedenlere bakıldığında kesici delici alet yaralanmalarının hepsinin önlenebilir nedenler olduğu ortaya çıkmıştır. Bu nedenlere yönelik etkin bir müdahale ile yaşanabilecek maddi-manevi zararların en aza indirilmesi beklenmektedir

Anahtar kelimeler: Kesici alet yaralanma, delici alet yaralanma, öğrenci, kök neden

Highlights

- Final-year nursing and midwifery students face high risk of sharp object injuries during clinical practice.
- Fishbone diagram used to identify root causes: personnel, equipment, environment, and procedures.
- 86.7% of participants reported experiencing at least one sharp object injury.
- All identified causes were preventable, indicating potential for effective interventions.
- Study offers a novel perspective to enhance safety awareness in clinical education

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Introduction

The Centers for Disease Control and Prevention (CDC) defines sharps injuries as "a penetrating stab wound from a needle, scalpel, or other sharp object that may result in exposure to blood or other body fluids". The CDC estimates that there are approximately 385000 sharps injuries per year (>1 000 injuries per day) among hospitalized healthcare workers (1).

Needle stick and sharps injuries potentially serious occupational injuries for healthcare professionals, including nursing students (2,3). Korkmaz et al. (2022) found that approximately two out of every five healthcare professionals had at least one needle stick/sharp piercing injury and that these injuries were frequently seen in surgical clinics. Approximately two out of every three people (63.9%) who reported having suffered an injury were nurses (4). The most important causes of needle stick/sharp piercing injuries are due to careless activities such as high labor force, fatigue, rushing, crowded working environment, two-handed capping, unsafe specimen collection, washing contaminated instruments, and disposal of sharps waste (5,6). Reasons such as nursing students' incompletely developed manual skills, limited clinical experience, and lack of attention to personal safety measures cause them to be in a higher risk group than working nurses in terms of sharps injuries (7-10). Therefore, from the first year of nursing education, students are frequently exposed to needle stick and sharps injuries during patient care in the hospital (11).

Needle stick/sharp piercing injuries negatively affect the psychological health, general productivity and quality of life of healthcare workers (12,13). Studies have shown that these injuries have a number of psychological effects such as fear, anxiety, depression and post-traumatic stress disorder (14). However, the estimated prevalence of these cases does not reflect the real scenario, as a significant proportion of them go unreported (15).

When the literature was reviewed, it was seen that the frequency of sharps injuries, knowledge levels and attitudes of healthcare workers were examined. As the original aspect of the study, this study was designed as a descriptive and prospective study to understand the root cause of the problems in sharps injuries by performing "root cause analysis" with "fishbone diagram" and to reveal the measures that can be taken in this direction.

Material and Methods

Study design

This qualıtatıve study was conducted descriptively and prospectively with 44 students who were reported to Sakarya University, Faculty of Health Sciences with a sharps injury between 2021 and 2023. The study sample consisted of 30 students who filled out the sharps injury form by the hospital, reported the sharps injury notification form to the student affairs and volunteered to participate in the study.

Data collection tools

1.Demographic Information Form: In the first part of the questionnaire; the grade level of the participants, their preference for the nursing/midwifery profession, the number of injuries with sharp instruments and the conditions that caused the injury, the clinic where the injury occurred

2. In the second part, a fishbone diagram will be used to identify the root causes of sharps injuries.

Fishbone Diagram

Developing prevention strategies as a result of root cause analysis of situations that threaten patient and employee safety plays a key role in preventing and reducing unexpected events. Measures to be taken in line with these strategies, new technical applications and suggestions on what can be done within the scope of employee safety and patient care and treatment are presented (16). Root cause analysis is defined as "the possible occurrence of an undesirable event, a process for identifying the root causes or influential factors underlying a change in performance". Root cause analysis is a structured approach that is widely used to analyze adverse events. The subject of investigation in root cause analysis is the event and its causes, not the people. The aim of this approach is not to find out who was negligent, but to make improvements in the system by reviewing all incidents (17).

Implementation of the Fishbone Diagram

In step 1, participants are brought together to brainstorm about the problem to be discussed.

In step 2, draw a large fish bone on the board.

In step 3, a sentence expressing the problem is written on the head of the fish.

In step 4, brainstorming is initiated on a category of potential causes.

In step 5, brainstorming continues on other categories.

The fishbone diagram is used to try to find the root cause of a problem and its solutions. In the first stage, a problem or a negative situation is written at the top of the fishbone diagram. In the second stage, the reasons that may cause this problem are tried to be identified and categorized. In the fishbone, basic causes such as human, material,

method, environment are identified. In the third stage, sub-causes are found by the participant(s). In the fourth stage, the most probable causes are ranked in order of importance (18).

Implementation and Ethical Aspects of Research

Permission was obtained from Sakarya University Ethics Committee and Sakarya University Faculty of Health Sciences for the implementation of the study. In the study, the data were applied by the researchers using face-to-face interview method. Students were gathered in a classroom on a common day when they came to school for lessons outside the application and data were obtained with a fishbone diagram.

Statistical analysis

The study data were evaluated using IBM SPSS Statistics 23; frequency distribution (number, percentage) for categorical variables, descriptive statistics (mean, standard deviation, minimum, maximum) for numerical variables and fishbone diagram were used.

Ethical Approval

This study was conducted in accordance with the Declaration of Helsinki and institutional ethical guidelines. The study approved by the Sakarya University Ethics Committee and Sakarya University Faculty of Health Sciences (Date: 15.05.2024. Number: 69/19). Informed consent was obtained from all patients. In the study, the data were applied by the researchers using face-to-face interview method. Students were gathered in a classroom on a common day when they came to school for lessons outside the application and data were obtained with a fishbone diagram.

Results

Eighty percent of the participants were female and 20% were male. The mean age was 22.30±0.702 (Min 21-Max 24). 76.7% of the students were nursing students, 23.3% were midwives, and all of them were 4th grade vocational education students. 83.3% of the students preferred the profession willingly. 46.7% of the participants practiced in internal units, 30% in surgical units and 23.3% in intensive care units. All of the students had received occupational health and safety training before practicing. While 86.7% of the participants had experienced a sharps injury once, 13.3% had experienced it for the second time. In the root cause analysis of students' sharps injuries according to the fishbone method, four main headings were identified: healthcare workers, material, environment and method **(Table 1) (Figure 1).**

Table 1. Results related to participants' demographic characteristics

		n	%
Sex	Male	6	20
	Female	24	80
Age, year	Mean ± SD (min-max)	22.30 ± 0.702 (21-24)	
Student department	Nursing	23	76.7
	Midwifery	7	23.3
Units	İnternal units	14	46.7
	Surgical units	9	30
	İntensive care units	7	23.3

Under the heading of health workers, it was found that students suffered injuries due to the fact that their work was intense due to the scarcity of employees and therefore they were fast and in a hurry.

Under the material heading, it was found that injuries occurred while closing the lid of the syringe in order not to put the used syringe openly in the tray due to the lack of a sharps waste box, similarly, they were injured by the needle left in the tray while using other medicines because the tray was too messy, and they were injured due to the lack of gloves or not suitable for their hands.

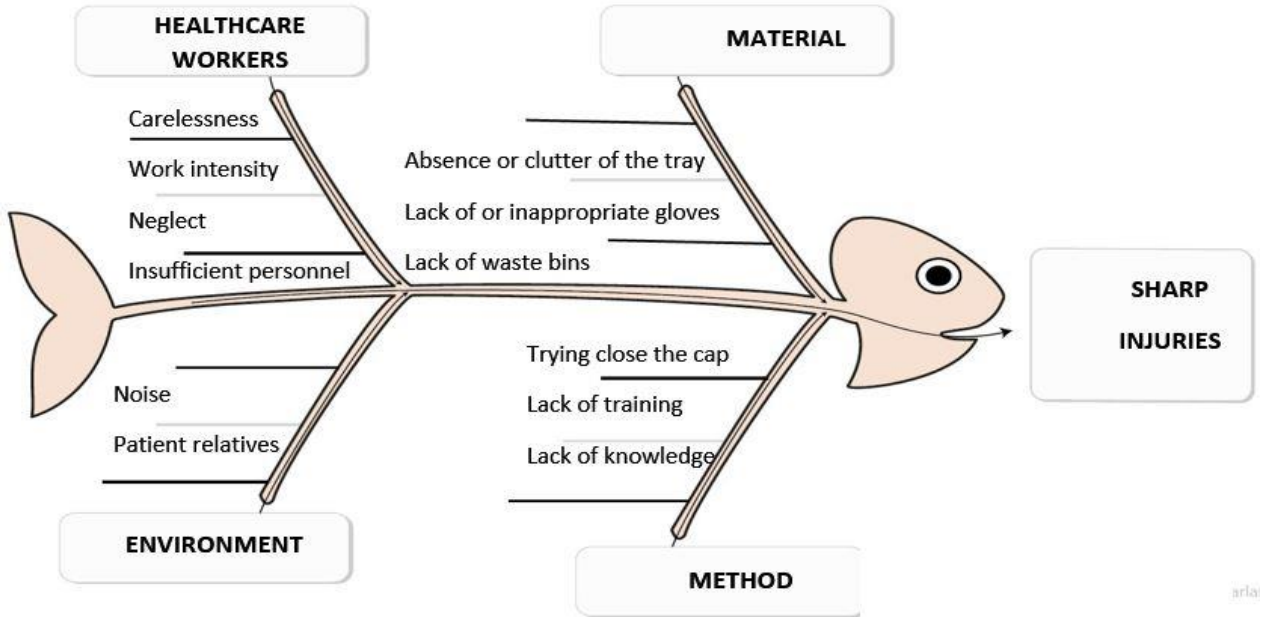

Figure 1. Fishbone Diagram

In the environment-induced sharps injuries, it was observed that the environment was very crowded and noisy due to the patient's relatives, and they were distracted and suffered a needle stick injury.
In another heading method, it was determined that the majority of the students were injured while trying to close the cap of the syringe and that there was a lack of information and education. It was determined that the students knew that they should not close the cap but somehow attempted to close it during the practice **(Table 2).**

Table 2. Main Reason- Sub Reasons

Healtcare workers	**Carelessness, work intensity, neglect, insufficient personnel**
Environment	Noise, patient relatives
Material	Absence or clutter of the tray, lack of or inappropriate gloves, lack of waste bins
Method	Trying close the cap, lack of training, lack of knowledge

Discussion

In the study, it was observed that the majority of the students were injured while closing the syringe cap, while in a similar study (2019), it was found that more than a quarter of nursing students experienced sharps injuries, and these injuries occurred especially while preparing treatment and closing the syringe cap. However, they also stated that a significant majority of the students (93.5%) did not report the injury, and two-thirds (70%) of the students who were exposed to the infectious agent did not make the necessary notification to the infection control committee (19).
In another study (2022), it was found that more than half of nursing students (56.6%) experienced needle stick injuries. Therefore, it is seen that lack of awareness among students is an important risk factor for injuries. It is also understood that students are careless with used and contaminated materials (20). In the study by Çalıkoğlu et al. (2019), it was determined that 21.6% of the participants experienced a needlestick or sharps injury in the last year, 16.7% of these injuries occurred while removing the needle tip from the syringe, 29.2% while trying to reattach the needle cap, 16.7% while filling the syringe and 12.5% while drawing blood from the patient (21).
Another study found that 18% of students had experienced accidental punctures with sharp objects in the last 12 months, with the most common sharp objects being syringe needles and insulin (22).
Palloş et al. (2024) found that 16.8% of students were exposed to sharp object injuries during their undergraduate education and that the injuries mostly occurred during clinical practice (95.7%) and in internal medicine clinics (57.4%). They found that 48.9% of students were injured in their first year and 63.8% were exposed to needlestick and sharp object injuries at least once, and the most common device causing the injury was the syringe needle (63.8%) (23).
Similarly, Smith et al. (2005). found that most needlestick injuries occurred in the nursing laboratory (45%) or teaching hospital (37%), with needle decapping being the most common causative event (24).

All of these studies collectively highlight that nursing students are highly vulnerable to needlestick and sharps injuries, most of which occur during clinical practice, particularly while handling syringe needles. The most common moments of injury include recapping the needle, removing the needle from the syringe, or during treatment preparation. Additionally, the high rate of unreported injuries and the insufficient number of notifications made to infection control units point to significant gaps in post-exposure management. These findings suggest that a lack of awareness among students, insufficient training and supervision, and inadequacies in clinical mentorship are critical risk factors. Therefore, in order to reduce the incidence of sharps injuries, it is essential to strengthen both theoretical and practical training, systematically educate students on the risks and prevention strategies, and encourage a more proactive approach to injury reporting.

Study limitations

This study has several limitations. The data were collected solely from nursing and midwifery students enrolled at a single institution, which limits the generalizability of the findings. Additionally, the study was conducted using a qualitative design and relied on participants' self-reported data. This may have introduced recall bias or response distortion due to social desirability or concerns about potential institutional repercussions.

Conclusion

In conclusion, the root causes of injuries identified according to the fishbone diagram were found to be preventable causes. To reduce such problems, instructors need to train students more efficiently and appropriate interventions are needed to guide and assist students in preventing and managing needle stick/sharp piercing injuries and to help them understand how to use protective equipment. For an effective intervention, it is of utmost importance to identify the possible risk factors that cause needle stick/ sharps injuries, especially among nursing students.

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References

1. Centers for Disease Control and Prevention (CDC). Preventing needlesticks and other sharps injuries [Internet]. 2023 [cited 2023 May 21]. Available from: https://search.cdc.gov/search/?query=Preventing%20Needlesticks%20and%20Other%20Sharps%20Injuries.
2. Chen M, Zhang L. Prevalence of needlestick injuries among nursing interns: A systematic review and meta-analysis. Ann Palliat Med. 2021;10(7):7525–33.
3. Agrawal T, Agrawal N, Gupta V, et al. Occupational exposure to needlestick injuries among health care workers in a tertiary care hospital: A KAP study. Indian J Community Health. 2022;34(2):234–40.
4. Korkmaz N, Şentürk GÇ, Tekin A, et al. Rates of underreported needlestick and sharps injuries among healthcare workers in Turkey: In the light of Infection Control Committee data. Int J Qual Health Care. 2022;34(2).
5. Alfulayw KH, Al-Otaibi ST, Alqahtani HA. Factors associated with needlestick injuries among healthcare workers: Implications for prevention. BMC Health Serv Res. 2021;21(1):1074.
6. Jahangiri M, Rostamabadi A, Hoboubi N, et al. Needle stick injuries and their related safety measures among nurses in a university hospital, Shiraz, Iran. Saf Health Work. 2016;7(1):72–7.
7. Demirdağ H, Yılmaz M, Gündüz O. Injury frequency and root cause analysis of students in sharps injuries in a state hospital. J Ege Univ Fac Nurs. 2018;34(2):23–9.
8. Eyi S, Eyi I. Nursing students' occupational health and safety problems in surgical clinical practice. SAGE Open. 2020;10(1):1–21.
9. Menteşe HÖ, Karaca A. Knowledge levels of nursing and midwifery students about sharps injuries. Klimik J. 2021;34(3):156–63.
10. Zhang X, Chen Y, Li Y, et al. Needlestick and sharps injuries among nursing students in Nanjing, China. Workplace Health Saf. 2018;66(6):276–84.
11. Abd-Ellatif Z, Radi F, Abdel Mowla H. Prevention of needle stick and sharp objects injuries among internship nursing students during their clinical exposure: An educational program at Assiut University Hospitals, Egypt. J Nurs Health Sci.

2018;7(2):93–100.
12. Alkan Ağaçdiken S, Ayar T. Objective quality of life and job satisfaction of operating room nurses. Samsun J Health Sci. 2017;2(1):23–37.
13. Diker H, Barsbay MÇ. Investigation of occupational accidents occurring in hospitals: The case of a state hospital. Hacettepe J Health Adm. 2023;26(1):99–114.
14. Hambridge K. The psychological impact of sharps injuries sustained by medical students. Br J Hosp Med. 2022;83(1):1–7.
15. Mishra R, Sharma SK, Gupta PK, et al. Occupational health cognizance: Needle stick injuries among student nurses. Int J Afr Nurs Sci. 2021; 15:100370.
16. Kaya SD. Root cause analysis: Scenario examples. Gümüşhane Univ J Health Sci. 2017;6(4):247–51.
17. Eraydın C, Tezcan B, Koç Z. Root cause analysis with fishbone method in the evaluation of patient falls. J Health Nurs Manag. 2019;6(3):266–72.
18. Bingöl Ü. Evaluation of health workers who applied to the emergency department with occupational accidents. İzmir Train Res Hosp Med J. 2022;26(2):161–6.
19. Çakar M, Şişman NY, Deniz O. Health risks encountered by nursing students in clinical practice. Dokuz Eylul Univ Fac Nurs Electron J. 2019;12(2):116–25.
20. Janjua SS, Hanan A, Sarwar H, et al. Awareness in nursing students regarding prevention of needle stick injuries. NURSEARCHER (J Nurs Midwifery Sci). 2022;2(1):20–4.
21. Çalıkoğlu EO, Bedir B, Akçay HB, et al. Needlestick and sharps injuries among nurses at Atatürk University research hospital and their practices after injury. Eur Res J. 2019;5(1):128-33.
22. Massaro T, Cavone D, Orlando G, et al. Infortuni da dispositivi taglienti tra gli studenti di infermieristica: un rischio lavorativo emergente [Needlestick and sharps injuries among nursing students: an emerging occupational risk]. G Ital Med Lav Ergon. 2007;29(3 Suppl):631-2.
23. Palloş A, Demirca K, Özkan S. Evaluation of Needlestick and Sharp Injuries, Contributing Factors, and Preventive Measures Among Nursing Students. CURARE - Journal of Nursing 2024; 6:21-9.
24. Smith DR, Leggat PA. Needlestick and sharps injuries among nursing students. J Adv Nurs. 2005;51(5):449-55.