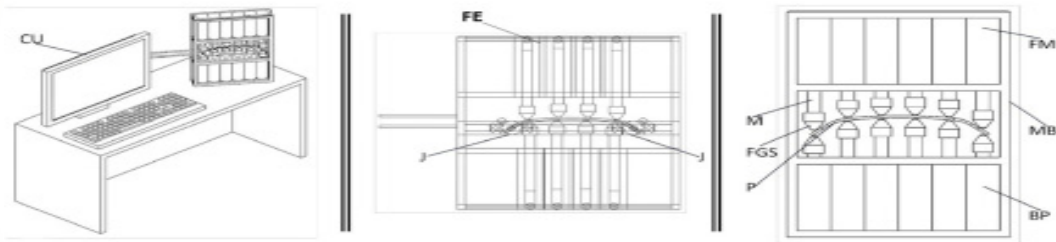


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Official e-Publication of:

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Original Article (Innovation)

An automatic bender for customized pectus bar

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ABSTRACT

Background: The present invention relates to a medical device that enables the “automatic” bending of the pectus bar. The curved bar is used in the correction of the deformities of the sunken chest (pectus excavatum) and the pigeon’s chest (pectus carinatum).

Materials and Methods: Conventionally, the surgeon shapes pectus bars manually during the surgery by trial/error method. In these surgeries, it may not be possible to give the ideal shape manually each time due to the complex anatomy of the patients’ deformity, which might lead to increases in the operation time and the risk of complications (organ injury, bleeding, etc.). The present invention aims to prepare a customized preoperative bent bar by using the CT coordinates of the deformity by the surgeon via a custom software. Besides, as an alternative method, as usual, the novel automated bender can copy a soft metal template.

Results: We presented this project to a few national and international companies. A national company has decided to take the project seriously about starting the process of producing the automatic bender to be used in the related field. The patent has protection both nationally and internationally.

Conclusions: This patent will probably change the clinical pectus bar bending process providing excellent results with high satisfaction rates for both the patients and the surgeons.

Keywords: thoracic wall, congenital abnormalities, patent, tomography, software

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Doi: 10.26663/cts.2020.00012

Received 25.03.2020 accepted 14.05.2020

Introduction

The Nuss procedure is now the preferred operation for the surgical correction of pectus excavatum (PE) [1]. It is a minimally invasive technique, whereby up to three curved metal bars are inserted behind the sternum to push it into a normal position. The bars are left in situ for three years and then removed. This procedure significantly improves the quality of life and, in most cases improves cardiac performance.

Pectus excavatum is the most common anomaly of the anterior chest wall. Correction of the PE significantly increases the quality of life for the patients and, in most cases improves their cardiac performance [2,3]. Since Ravitch published his first paper in 1949, a modified Ravitch approach with resection of cartilage has been the preferred operation for surgical correction of PE in most surgical units [4]. After Nuss published his minimally invasive Nuss procedure in 1998, whereby curved bars are inserted behind the sternum to position it anteriorly, it has changed the treatment of PE and become the most commonly used technique [5]. It results in improved cosmesis regarding both the shape of the anterior chest wall and the absence of an incision anterior to the sternum.

The original technique, the bar bending, is being performed “manually” using a soft metal template that gets the shape of the patients’ chest wall deformity. This novel invention facilitates and improves the accuracy of the bar bending process. The bender copies the soft metal template as in the classical method. Besides, it uses the digital coordinates of the chest wall deformity acquired through the custom software that extracts the coordinates of the chest wall deformity from 3D-CT images. The bender uses the coordinates to bend the pectus bar that is placed into the automatic bender preoperatively (pre-bent bar). The bender can also curve the bar during the surgery as needed to get optimal results in shorter surgery time.

In this manuscript, we described this novel pectus bar bending system in detail.

Materials and Methods

Surgeons bend the pectus bars manually in the present setting. The surgeon determines the final form of the patient’s deformity using a soft metal template while the patient is lying in the supine position. Then, using the bending tools on the back table, the surgeon tries to give the shape of the soft metal template to the original metal bar to be used for the patient. This is not always the

case, especially in complicated asymmetric deformities and in the hands of inexperienced surgeons.

The present invention makes this process more precise, more accessible, and automated. The physicians will have two options for the bending process. First, they can use the soft metal template (conventional method) and second preoperative 3D-CT (thorax) coordinates of the deformity to bend the pectus bar accordingly. The surgeon can use the cursor on the monitor to determine the shape, length, and entry and exit points of the metal bar. The desired optimal shape to the original pectus bar can be generated before and during the surgery as well.

The provisional patent application (TKNK/030059/000060) (Specification: 30.10.2017) is completed in collaboration with Boğaziçi University, Institute of Biomedical Engineering. The patent owner is now the Boğaziçi University. We have prepared a clinical trial project related to the novel bar bender. It was necessary to prepare the ethics committee document from the front. We had to clarify the financial resources for the study. We applied for support to our project to The Scientific and Technological Research Council of Turkey. However, due to not being in University staff, our application is rejected. Upon searching for financial assistance, we came across the Small and Medium Enterprises Development Organization of Turkey (KOSGEB) supports. The new plan is to transfer the patent right of use to a biotechnical company located in Ankara to apply for the KOSGEB support and produce our product to be used in the clinical setting.

After producing the automated bender machine, the plan is to bring it to the clinics who needs and who are allocated in the clinical trial free in the first year. Besides, we will provide the pre-bent bars to the clinics which request remotely (bar cost will be charged). After the first year, we will charge an affordable price for both the whole bender machine and the pre-bending process.

Results

The “Automatic Bar Bender” is seen in Figures 1a-c and Figure 2. Besides, the initial prototype is watched at the Video -1 and Video -2 and the photo.

Video-1. The initial prototype of “Automatic Bar Bender” (real), <http://cts.tgcd.org.tr/uploads/482-video1.mp4>

Video-2. Animated application for bar bending. <http://cts.tgcd.org.tr/uploads/482-video2.mp4>

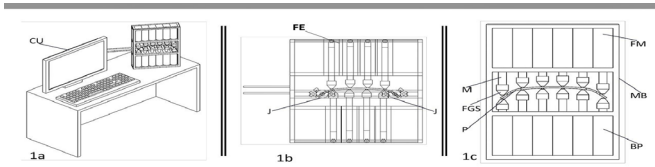


Figure 1a-c. The “Automatic Pectus Bar Bender”; (a), This is a perspective view of the bar bending device of the first preferred embodiment of the Innovative Device, (b) This is a front view of the bar bending device of the second preferred embodiment of the Innovative Device, (c) This is a front view of the bar bending device of the first preferred embodiment of the Innovative Device in which a pectus bar is bent by the pistons.

Abbrev.: BP (Bottom Pistons); MB (Main Body); FM (First Motor); M (Shaft); FE (First Encoders); FGS (Force Gauge Sensors); CU (Control Unit); J (Jaw); P (Pectus Bar).

Our First Prototype

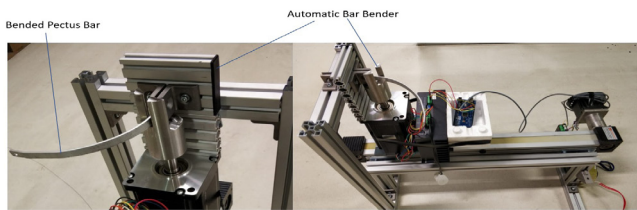


Figure 2: Picture of the initial Prototype (with only one motor)

Figure 2. Picture of our first initial prototype (with only one motor).

In the present invention, a soft metal-based guide strip bar, which is pre-shaped manually by placing directly on the skin of the patient’s deformity (as in the current clinical setting), could be copied by the automatic bender machine using a key-copying method. There is no need to use manual benders easing the bar shaping process for all surgeons in the field.

Besides, the new bender machine could get the 3D-CT coordinates of each patients’ deformity to process. The encoder, which has the geometry of the deformity, is then inserted into the two rows of pistons of the automatic pectus bar-bending device and advanced from the initial position until each piston contacts the guide bar. The length of the piston shaft at the point where the force sensors contact the guide is connected to each piston separately. The automatic bender takes into account the 3D-CT coordinates during the whole bending process to get an optimal result for shaping the pectus bar.

Thanks to the control unit, the relevant coordinates are recorded. In this way, the deformity geometry of the patient can be transferred to the digital environment in a much cheaper and practical way without the need for expensive medical imaging methods. Then the shape that the pectus bar should take to correct this deformity

is created by the software of the device and finalized by the surgeon. The final bar geometry is applied to the pectus bar, which is initially placed flat within the bar shaping device.

Detailed Description of the Innovative Device

A preferred embodiment of the Innovative Device is shown in (Figures 1a-c). In this form, the hydraulic or pneumatic base pistons (BP), which can move independently of each other, are placed in the main body (MB) in the form of two rows in a single plane. To move the pistons, initial motors (FM: preferably servo-motor) connected to each piston shafts (M) and controlled in a forward/reverse motion, and encoders (FE) connected to these initial motors. Sensors (FGS; e.g., force gauge sensors) are disposed at the second facing ends of the oppositely disposed pistons (BP). The data from these FGS and the data received from the initial encoders (FE) are recorded, processed by a control unit, and the necessary electrical signals controlling the first motors (FM) are generated and transmitted to the said initial motors (FM).

The control unit of automatic bar bender comprises a processor, memory unit, data input interface (e.g., keyboard, mouse, touch screen, etc.), a data input connector that provides a data connection between the main body (MB) and or Bluetooth, Wi-Fi and so on. An electronic device comprising a wireless data communication module such as a desktop computer, laptop computer, tablet computer, and the like can be any electronic device. Besides, this control unit comprises a graphical user interface for communicating with the user and a display device like a monitor, touch screen, etc., for displaying this graphical user interface to the user.

In the second embodiment of the Innovative Device, at least one-third motor including at least one-third encoder (rotational encoder) which can be rotated about the central axis, which can be moved independently of one another, besides the hydraulic or pneumatic bottom pistons (BP) positioned perpendicular to the pectus bar (P) and at least one jaw (J) rotated by said at least one-third motor (preferably servo motor).

In this embodiment of the present Innovative Device, this control unit (CU) comprises of a desktop computer, laptop computer with a data input connector (or a wireless data communication module such as Bluetooth, Wi-Fi, etc.) that provides a data connection between the processor, memory unit, a data input interface

(e.g., keyboard, mouse, etc.), MB, tablet computer, etc., can be any device. Besides, this CU comprises a display device with a graphical user interface for communicating with the user and a monitor, touch screen, etc., for displaying this graphical user interface to the user.

As described technically above, the idea is to bend the pectus bar automatically either by key copying method using the standard bent soft metal template and the 3D-CT image coordinates of the chest wall deformity for creating an ideal bent pectus bar customized for each patient.

Discussion

The Ravitch procedure was developed for the surgical treatment of congenital chest wall deformities, including pectus excavatum and pectus carinatum. These congenital abnormalities are thought to result from an abnormal overgrowth of the rib cartilage adjacent to the sternum, displacing the sternum anteriorly, resulting in pectus carinatum; posteriorly, resulting in pectus excavatum; or both anteriorly and posteriorly, resulting in an asymmetric deformity [6].

Pectus excavatum may be noted at birth and may become more pronounced when the child experiences rapid skeletal growth during adolescence. The exact mechanism underlying abnormal cartilage growth in pectus deformities is unknown.

Ravitch proposed the first technique of pectus excavatum repair in 1949, an open method that required partial resection of the cartilage, xiphoid excision, and osteotomy of the sternum [4]. Since then, surgical procedures have evolved towards more minimally invasive techniques. The introduction of the Nuss procedure (1998) was a radical paradigm shift [7].

The Nuss procedure is a minimally invasive alternative to the Ravitch procedure for the treatment of pectus deformities. It involves only internal bracing without resection of the abnormal cartilage [8]. It aims to force the sternum forward and hold it there with an implanted steel bar, but without performing a long incision to resect the abnormal cartilage [5]. In this procedure, the curved steel bar is placed under the sternum through two small incisions on the sides of the chest wall. Because the sternum is forced outward and held under high-pressure, the Nuss procedure results in more pain and discomfort than the modified Ravitch procedure.

The steel struts must remain in place for approximately 2-4 years to properly reform the chest.

While less invasive than the Ravitch procedure, the initial Nuss procedure surgery still requires 4-5 days of hospitalization for pain management due to the rather drastic change in chest shape [9]. Full recovery can take several weeks, during which time the patient's physical activities are restricted. For both the modified Ravitch and the Nuss procedures, the bar removal operation is a much simpler outpatient surgery, and the patient can usually leave within a couple of hours.

In conventional surgical corrections for pectus deformity, one or two metal bars (Lorenz Bars) are selected according to the patient, the depth and extent of the deformity. These pectus bars are placed under the sternum under general anesthesia with video-assisted thoracoscopic surgery (VATS). The Lorenz bar is brought to its final shape manually during the operation by using shaping, curving, and corrective hand tools on the back-table. This process can take 25-30 minutes in the competent hands, but in the inexperienced hands, it can take longer than one hour. It may need to be repeated several times during the surgery, which might increase the surgical complications such as organ injury, bleeding, prolonging of the procedure and the anesthesia time, etc.

To our knowledge, there is no automatic bender/molder in the literature using both the copying of the standard soft metal template and also the 3D-CT image coordinates of the chest wall deformities to bend the original pectus bar pre and intraoperatively.

In summary, the prostheses (pectus bars) used in pectus excavatum and carinatum deformities are shaped by the surgeon during the surgery by trial/error method, as mentioned above. In these surgeries, it may not be possible to give the ideal shape each time, depending on the complex asymmetric anatomy of the patient's deformity during the bending of the bar specific to the patient by using bending hand tools.

Besides, since the desired geometry can be achieved at one time during this process, which requires physical strength and experience, it is often necessary to repeat this process several times during the insertion process of the bar. In other words, after placing the pectus bar under the sternum at the required level, it is most of the time necessary to remove it again outside the body when some final corrections and re-insertion processes

are needed. Re-insertion sessions lead to an increased risk of complications (organ injury, bleeding, etc.) as well as prolonging the surgery time and late complications as prolonged pain, displacement of the bar, and even fracture of the bar.

This new patent-pending apparatus would ease and shorten the bending process of the pectus bar and increase the possibility of optimally bending a customized bar for each patient. The unique bending process could decrease the complications rates, the time for surgery and hospital stay, and on the contrary, increase the success rates and the patients' satisfaction rates.

In conclusion, the benefits for such 'an automatic bar bender' are providing a customized optimal bar shape for each patient, which decreases the complication rates and the time for the surgery, anesthesia, and hospital stay.

Additionally, such a process could ease the optimal bar bending process helping all thoracic surgeons who wish to perform the non-invasive pectus surgery with a high success rate.

Lastly, after the analyses of the 3D-CT coordinates using the specific software, a report including suggestions for the optimal bar insertion and exit points, optimal bar length, and bar numbers to be used, the Haller Index and the volume of the sunken deformity could be given to the surgeon.

To sum up, all described points related to such a new automatic bar bender could change the game played in the field of pectus surgery.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received financial support from Small and Medium Enterprises Development Organization of Turkey (KOSGEB) for the research.

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Original Article

Impact of weather conditions and blood groups on primary spontaneous pneumothorax

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ABSTRACT

Background: Primary spontaneous pneumothorax (PSP) is a clinical condition with an unclear etiology that occurs because of the rupture of pleural bulla or blebs. Several studies indicating the impact of weather conditions on PSP are present. However, the results are varying. The correlation between blood groups and PSP is yet unknown. In this study, we investigated the impact of altering weather conditions atmospheric pressure (AP), temperature, moisture, and wind velocity (WV) and blood groups on PSP.

Materials and Methods: Eighty-six patients PSP diagnoses who were under follow-up and treated in our clinic between 2007 and 2015 were included in our study. Patients' data were retrospectively collected from hospital database patient files. The Regional Directorate of Meteorology provided data on weather conditions.

Results: The collected data was examined. According to the results, AP and WV had no significant impact on PSP. Regarding the air temperature, values were statistically significantly high ($p = 0.019$). When comparing with other blood groups, the blood group with the highest resistance to temperature was type-0. This result was statistically significant ($p = 0.029$).

Conclusions: In this study, we determined that temperatures above 15°C had an unexpected effect on the site of the PSP. Surprisingly, PSP risk was lower in patients with blood type-0 at high temperatures. We suggest that multicenter studies with a more extensive sample size should be conducted to fully understand the impact of air condition and blood type on PSP.

Keywords: air condition, blood group, primary spontaneous pneumothorax

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Doi: 10.26663/cts.2020.00013

Received 25.03.2020 accepted 14.05.2020

Introduction

Primary spontaneous pneumothorax (PSP) is defined as the presence of air in the thoracic cavity without trauma, and symptoms include chest pain and shortness of breath [1-4]. In general, there is no underlying pulmonary disease [4-7]. PSP is thought to be developed due to air leakage as a result of the rupture of alveolar structures to the pleural space [5-7].

According to some authors, PSP cases occur in short periods, and it was suggested that this might develop due to transpulmonary pressure differences based on the weather changes [2,3,8]. Again, some authors suggest that PSP is a type of meteoropathia occurring in unexpectedly low atmospheric pressures (AP) [5,6]. Although many studies have been conducted on etiology, PSP is still a manifestation of uncertainty [9]. Though not fully proven, it is thought to be associated with changes in the weather conditions [2,3,8,10,11].

To our knowledge, in the English literature, there is no study or researches done investigating the correlation between blood groups and PSP. In our study, we investigated the impact of weather conditions (atmospheric pressure (AP), temperature, moisture, and wind velocity (WV)) and blood groups on PSP.

Materials and Methods

86 patients with PSP diagnoses who were followed up in our clinic between 2007 and 2015 were included in the study. The age, gender, blood group, and applied treatment data were retrospectively scanned from the patient files. The patients were diagnosed with posteroanterior (PA) X-ray in the emergency department. Patients who were diagnosed with iatrogenic, traumatic, or secondary pneumothorax were not included. This study was approved by the Ethics Committee of Selçuk University (Letter no: 2017/325).

Meteorological Data

Meteorological data were provided from the Regional Directorate of Meteorology. Temperature (°C), moisture (%), air pressure (hPa), and wind velocity (m/sec) values between 2007 and 2015 were assessed. Meteorology values of the patients' application day and four days before the application were assessed for therapeutic purposes.

Statistical Analysis

The statistical analyses of the study were performed with SPSS 21 software. Of the numerical values in the study, temperature and wind velocity parameters were analyzed with the Shapiro-Wilk test and hypothesis, ensuring approach to normal distribution was rejected. Therefore, the statistical analysis of these parameters was examined with One Way ANOVA, which is a parametric test, and the independent t-test. When analyzing moisture, air pressure, and WBC variables with the Shapiro-Wilk test, the hypothesis ensuring the approach of the present parameters to normal distribution was rejected. Thus, the mentioned parameters were analyzed with the nonparametric Kruskal Wallis and Mann Whitney U tests. During the research phase, since "days without disease" were not detected, literature research was conducted to review the differences between days with and without the disease. In line with the reviewed studies, it was seen that temperature from meteorological data tended to be averagely 15°C on days with the disease. Based on this data, some evaluations were made, and meaningful results were achieved. Moreover, definitive statistics for categorical variables were expressed as "n" and percentage, while statistics for numerical variables were expressed as minimum-maximum value and mean- standard deviation. In all analysis techniques, an error level of 0.05 was considered, and, thus, decisions were made at a confidence interval of 95%.

Results

According to the population census in 2007, the population of the city our study was conducted in was 638,464, and the altitude of the location was 1,285 m. The study was performed in the Middle-Anatolian region with an arid climate. 86 PSP cases were investigated. Of the cases, 74 (86%) were male, and the mean age was 37.34 ± 16.12 years. When analyzing patient files, the blood type of 61.6% of the patients was type-A, 15.1% was the type- B, 16.3% 0, and 7% was type-AB. Right site pneumothorax was seen in 65.1% of the patients. Descriptive features of patient results and treatment methods are presented in Table 1.

Table 1. Descriptive features of PSP patients.

		Mean±standard deviation	Frequency values (%)
Age		37.34±16.12	-
Gender	Male	-	74-86%
	Female	-	12-14%
Site	Right	-	56-65.1%
	Left	-	30-34.9%
Treatment	Bulla excision	-	10-11.6%
	Tube thoracostomy	-	49-57.0%
	Thoracentesis	-	2-2.3%
	Nasal oxygen	-	16-18.6%
	Tube thoracostomy - Bulla excision	-	6-7.0%
	Thoracentesis - Nasal oxygen	-	2-2.3%
	Tube thoracostomy - VATS	-	1-1.2%
Blood Groups	A	-	53-61.6%
	B	-	13-15.1%
	O	-	14-16.3%
	AB	-	6-7.0%

While mean air temperature at the time of admission to the healthcare facility was detected as $9.88 \pm 9.04^{\circ}\text{C}$, the moisture was found as $61.72 \pm 12.34\%$. Moreover, mean air pressure was identified as 871.53 ± 3.834 hPa, while wind velocity was detected as 2.569 ± 0.740 m/sec. Meteorological values were calculated on the day of patients' admission to the hospital and the four days before the admission (Table 2).

Table 2. The meteorological data.

Air Condition	Mean±Standard Deviation
Temperature ($^{\circ}\text{C}$)*	9.88 ± 9.04
Moisture (%)*	61.72 ± 12.34
Air pressure (hPa)*	871.53 ± 3.834
Wind velocity (m/sec)*	2.569 ± 0.740

**Meteorological findings were calculated upon the mean of the day of patient's admission to the hospital with the therapeutical aim and 4 days before.*

Considering a cut-off value of 15°C , we reviewed the impact of meteorological parameters on PSP in two different periods, one with the temperature above and one under this value, separately. At $>15^{\circ}\text{C}$, the mean temperature during the period when patients experiencing a pneumothorax attack on the right site applied to the hospital was found $19.87 \pm 3.18^{\circ}\text{C}$, while this was found as $17.61 \pm 1.83^{\circ}\text{C}$ during the period when patients were experiencing an attack on the left side, and this difference was found to be statistically significant ($p = 0.019$) (Table 3).

While mean moisture was found $49.66 \pm 9.75\%$ during the period when patients with PSP on the right site applied to the hospital, this value was $57.12 \pm 8.11\%$ with patients with left-side PSP. In addition, these values were found to be statistically significantly high ($p = 0.041$) (Table 3).

Table 3. Descriptive features on PSP patient's results at temperatures above 15°C .

		Temperature	Moisture	Air pressure	Wind velocity	WBC
Site*	Right	19.87 ± 3.18	49.66 ± 9.75	871.20 ± 2.68	3.05 ± 0.71	9769.56 ± 3262.79
	Left	17.61 ± 1.83	57.12 ± 8.11	871.80 ± 1.78	2.85 ± 0.65	8611.11 ± 2686.74
p Value		0.019	0.041	0.472	0.468	0.317
Blood Groups*	A	19.04 ± 2.88	50.17 ± 10.57	871.42 ± 2.14	3.08 ± 0.63	10026.31 ± 3357.22
	B	18.29 ± 2.41	55.28 ± 3.91	871.06 ± 3.31	3.15 ± 0.70	8066.66 ± 3013.08
	O	23.92 ± 3.06	50.63 ± 14.88	869.71 ± 1.49	2.54 ± 0.94	10100.00 ± 2151.74
	AB	18.09 ± 1.65	54.84 ± 9.72	872.85 ± 3.00	2.70 ± 0.82	8250.00 ± 2469.14
p Value		0.029	0.658	0.468	0.317	0.476

**Results belong are from the period with the temperature above 15°C .*

While air temperature during the period when patients with blood type-A applied to the hospital was $19.04 \pm 2.88^{\circ}\text{C}$, this value was $18.29 \pm 2.41^{\circ}\text{C}$ for blood type-B, $23.92 \pm 3.06^{\circ}\text{C}$ for type-0 and $18.09 \pm 1.65^{\circ}\text{C}$ type-AB. When comparing with other blood types, the most temperature-resistant ones were the patients with blood type-0. This difference was found as statistically significant ($p = 0.029$) (Table 3). There was no statistical correlation between the PSP side and air temperatures below 15°C ($p = 0.483$). Again no statistical difference was found between the PSP side and the mean air pressure values ($p = 0.763$). At the hottest period, patients that applied to the hospital were found to be blood type-AB, while at the coldest temperature values, type-B applied dominantly. However, this present difference was not statistically significant ($p = 0.173$). When investigating both periods separately, a significant impact of AP and WV on SP was found.

Discussion

According to the literature, meteorological events play a role in the pathogenesis of various diseases. These include many diseases, ranging from sudden hearing loss to facial paralysis, from arthritis to rupture of abdominal aortic aneurysm. One of the diseases whose pathogenesis is thought to be affected by changes in weather conditions is spontaneous pneumothorax. Changes in weather conditions may change airway pressure. The visceral pleura covering the blebs is weak. Therefore, blebs are capable of tearing. Moreover, changes in airway pressure can cause blebs to rupture. There are many studies in the literature regarding this issue [7].

Meteorological events in our city that occurred during the period PSP was seen were investigated. When we assessed the achieved data, we found that changes in AP and WV had no impact on PSP. Regarding this fact, studies have found variable results in the literature. Yamaç et al reported that there was no correlation between the frequency of spontaneous pneumothorax (SP) and AP alterations. However, it was seen that primary SP appears to occur more frequently in fall and secondary SP in summer. Again, in their study, an association between moisture and SP was found. Also, they concluded that wind velocity was slower on SP days [2]. In another study by Çelik et al, it was also observed that AP, temperature, and moisture showed no significant difference on days with and without SP. Although they considered

that SP episodes are more frequent in June and November, the results were not statistically significant [3]. In our study, we found a significant difference between moisture and the site of pneumothorax. We suggest that this difference is due to the anatomic variation of hemithoraxes. Alifano et al demonstrated that there was no correlation between atmospheric temperature and SP groups, and AP had no impact on SP, but that it caused an increase of symptoms, contributing to diagnosis. In contrast, when analyzing minimum and maximum AP values on the baseline and the day before, a correlation was identified. SP and stormy days were found to be strongly correlated [5]. The results of the study by Smit et al. showed that AP had no impact on SP. However, they found that temperature alteration is correlated with SP [6]. Obuchi et al. support our results about the impact of AP on SP [10].

Bertolaccini et al demonstrated a correlation between daily WV and SP. However, no association between alteration in AP and temperature and SP was found [12]. Besides, Scott et al showed no strong relation between AP alterations and SP [13]. In terms of AP and impact on SP, in the most extensive series in literature published by Haga et al in 2012, it was shown that the decrease of AP played a significant role in the occurrence of SP [1]. In the study by Özpölat et al, no significant correlation between SP and season and months was shown [7]. In the study by Vodicka et al, significant differences in air temperature on days when SP was seen was identified. Although they had shown that WV is higher on days when SP occurred, it was shown that the storm had no impact on SP. They have shown a significant correlation between AP and SP [8]. Araz et al demonstrated that SP was associated with air-related factors and that AP, moisture, and temperature had an impact on SP development [9]. Obuchi et al had shown that a decrease in sunny days and an increase of temperature two days before was efficient on SP occurrence [10]. Mishina et al had identified that a decrease in AP had an indirect impact on SP development and that AP alteration on days of SP development was inefficient, while AP changes 24-96 hours before had an impact on SP development [11]. Diversely, in our study, we identified that temperature values above 15°C and moisture parameters had no unexpected impact on the side of SP. Surprisingly, patients with blood type-0 were at lower SP risk at high temperatures. We think this is related to the absence of

A and B antigens in that blood group. The limited number of patients restricted our study.

When scanning the literature, we saw that studies were conducted at different altitudes in countries and cities with different climates. Thus, we consider that this fact may have caused to the achievement of various results.

The main limitation of this study is the limited number of cases.

In conclusion, to fully understand the impact of air condition and blood group on PS and each other, we suggest that multicenter and more extensive studies with similar altitudes and climatic factors should be conducted.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

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To cite this article: İnan K, İnan MŞ, Bıçakçioğlu P, Gülhan ŞŞE, Aydoğdu K, Kaya S, Fındık G. The surgical management in pneumonectomy cases for lung cancer treatment. *Curr Thorac Surg* 2020; 5(2): 64-70.

Original Article

The surgical management in pneumonectomy cases for lung cancer treatment

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ABSTRACT

Background: Lung cancer is placed in first rows among all types of cancer in both women and men. Treatment options include surgical resection, chemotherapy, and radiotherapy. The main factor, which determines the treatment, is the stage of the disease. Several factors should be considered when assessing the survey ratios of the patients.

Materials and Methods: We retrospectively evaluated the patients that we performed pneumonectomy owing to lung cancer from January 2009 to December 2014. Classical and extended pneumonectomies due to non-small cell lung carcinoma were included in the study while excluding the patients who have given neoadjuvant chemotherapy and radiotherapy. We analyzed patients for age, gender, complaints, symptoms, diagnostic steps, pathological specifics, postoperative complications, and surveys.

Results: We evaluated 192 patients retrospectively. The mean age was 58 years. Eight of these patients were female and 184 of them were male. The most common complaint was shortness of breath. We operated 55 patients on right and 137 patients on the left hemithorax. 45 patients were given both chemotherapy and radiotherapy, 79 patients only chemotherapy, 2 patients only radiotherapy, and 66 patients did not take any additional treatment. During the follow-up period, we determined metastases in 15 patients, recurrence in 20 patients, and a second primer tumor in 1 patient. The most common postoperative complication was empyema with fistula. The mean hospital stay was 13 days. 5 years of survival was 35.9%.

Conclusions: The five-year overall survival found to be significantly higher compared to the literature. Despite its unwilling morbidity rate and high mortality rate, pneumonectomy is a surgery to prolong survival in selected cases of lung cancer.

Keywords: lung cancer, pneumonectomy, survival

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Doi: 10.26663/cts.2020.00014

Received 08.12.2019 accepted 10.02.2020

Introduction

Lung cancer constitutes 12-16% of all cancers and is responsible for 18-28% of cancer-related deaths [1]. There are options such as surgery, chemotherapy, and radiotherapy in lung cancer treatment. These treatment methods are applied alone or in combination. The 5-year survival rate of lung cancer was 14% despite improved diagnostic methods, advanced surgical techniques, and non-surgical methods [2].

Even though surgery is the most important treatment for non-small cell lung cancer (NSCLC), curative complete resection rate is 20% when diagnosed. For long-term survival, treatment modality can only be decided by a correct staging [3].

In this study, we investigated the factors affecting the survival rate of patients who underwent pneumonectomy for NSCLC.

Materials and Methods

Between January 2009 and December 2014, 270 patients underwent pneumonectomy in Ataturk Chest Diseases and Chest Surgery Training and Research Hospital Chest Surgery Clinic. Benign causes, mesotheliomas, and pneumonectomies after neoadjuvant chemotherapy were excluded from the study. While sleeve and completion pneumonectomies are excluded, pneumonectomies that caused by synchronous tumors and extended pneumonectomies were included in the study. In the end, 192 patients were examined retrospectively. Both the data systems of the digital environment and archive files have been examined.

Patients' age at operation time, gender, complaint, background, family history, drug use, PET-CT (positron emission tomography-computed tomography), respiratory function tests, bronchoscopy, preoperative diagnosis, preoperative diagnostic methods, postoperative pathology and staging, chemotherapy, radiotherapy, survival, postoperative hospital stay, development of complications, relapse and metastasis were investigated. Survival information was obtained from the Ministry of Health Death Notification System. The study was approved by the local education committee (No: 2016/529) and was designed in accordance with the principles of the Declaration of Helsinki. The study is the thesis of the first author, and the data of the patients managed between 2009 and 2014 we used.

Statistical Analysis

SPSS 23.0 (IBM Corp., Amonk, NY, USA) was used for statistical analyses. As descriptive statistics, minimum-maximum values and arithmetic mean $\pm$ standard deviation and numbers and percentages related to qualitative data were calculated. The conformity of the measurable data to normal distribution was checked with a single sample Kolmogorov-Smirnov test. Mann-Whitney U was used for comparisons between groups and Wilcoxon paired-sample tests were used for comparisons within the group. In qualitative data, Pearson chi-square and single example chi-square tests and Fisher's exact chi-square tests were used. Survival events were evaluated by Kaplan Meier analyses. P values <0.05 were considered significant.

Results

The mean age of the patients (n = 192) was 58. Patients were between 38 and 80 years old .184 patients were male (95.8%) and 8 were female (4.2%). The most frequent complaint was the shortness of breath with a rate of 35.9%. 10.4% (n = 20) of the patients had no history of using cigarettes, 2.4% (n = 5) of them had used less than 20 packets per year while 72.4% (n = 139) of the patients (n = 28) had used more than 20 packets per year and 14.6% (n = 28) of them had stopped using. While there was no sign of any malignancy in family history in 89.6% of the patients (n = 172), respiratory malignancies were detected in 7.3% (n = 14), family, and non-respiratory malignancies in 3.1% (n = 6). The Charlson comorbidity score was zero in 64.1% of the patients (n = 123).

72.9% of the patients (n = 140) were diagnosed by flexible bronchoscopy. The most common lesion was found in the left upper lobe bronchus with 34.4% (n = 66). Left pneumonectomy was performed in 71.4% (n = 137) and right pneumonectomy in 28.6% (n = 55) of all patients. The average hospital stay was 13 days. In 94.8% of patients (n = 182) bronchial surgery border was negative.

While 34.4% (n = 66) of the patients did not receive chemotherapy and radiotherapy, 41.1% received chemotherapy, 1% received radiotherapy and 23.4% received chemoradiotherapy.

One month, 1, 2, 3, 4, and 5 years survival of patients were evaluated. Since not all of the patients completed a

5-year postoperative period, the number of patient groups assessed at 3, 4, 5-year survival rates varied (Table 1).

Table 1. 5-year of survival.

	Number	%
Exitus	66	64.1
Alive for >5 year	37	35.9
Total patients	103	100

When we compared the survival times with the operation side, we could not obtain a meaningful result.

Survival was compared according to their histopathological diagnosis. There was no significant difference between the groups (Table 2).

Similarly, no statistically significant difference was found between the histopathologic groups by the rates of metastasis, relapse and secondary primer development ($p = 0.9$) (Table 3).

Table 2. Distribution of postoperative histopathologic diagnosis and survival.

	n (%)	30 day	1 year	2 years	3 years	4 years	5 years
Adenocarcinoma	17 (8.9)	17	14	8	7	5	3
Squamous cell carcinoma	136 (70.8)	132	107	82	60	48	26
Adenoid cystic carcinoma	1 (0.5)	1	1	1	1	1	1
Atypical carcinoid	2 (1.0)	2	2	2	2	2	2
Typical carcinoid	1 (0.5)	1	1	1	1	1	1
Combination of squamous and giant cell	1 (0.5)	1	1	1	1	1	1
Large cell carcinoma	7 (3.6)	7	4	4	3	1	0
Adenosquamous carcinoma	23 (12.0)	22	16	10	7	4	3
Mix germ cell carcinoma	1 (0.5)	1	0	0	0	0	0
Pleomorphic carcinoma	3 (1.6)	3	3	2	1	1	0
Total	192 (100)	187	149	111	83	64	37
P value		0.9	0.4	0.5	0.4	0.1	0.09

Table 3. Survival according to recurrence-metastasis-secondary primary status.

	No Recurrence/ metastasis (n=156)	Metastasis (n=15)	Recurrence (n=20)	Secondary primary (n=1)	p
30 day	151 (96.8%)	15 (100%)	20 (100%)	1 (100%)	0.7
1 year	118 (75.6%)	11 (73.3%)	19 (95.0%)	1 (100%)	0.2
2 years	89 (57.1%)	8 (53.3%)	13 (65.0%)	1 (100%)	0.7
3 years	70 (53.0%)	4 (28.6%)	8 (42.1%)	1 (100%)	0.2
4 years	55 (46.2%)	2 (16.7%)	6 (37.5%)	1 (100%)	0.1
5 years	33 (38.4%)	1 (16.7%)	2 (20.0%)	1 (100%)	0.2

A significant difference was observed in the first 30 days when patients with and without chemoradiotherapy were compared (Table 4).

Table 4. Survival by chemotherapy and radiotherapy.

	No CT-RT (n=66) (%)	CT (n=79) (%)	RT (n=2) (%)	Both CT-RT (n=45) (%)	Total (n=192) (%)	p
30 day	61 (92.4)	79 (100)	2 (100)	45 (100)	187 (97.3)	0.02
1 year	44 (66.7)	66 (83.5)	2 (100)	37 (82.2)	149 (77.6)	0.06
2 years	21 (81.8)	51 (85.4)	2 (100)	27 (90.4)	111 (57.8)	0.1
3 years	22 (40.0)	40 (58.8)	1 (50)	20 (48.8)	83 (50.0)	0.2
4 years	17 (25.7)	31 (51.7)	1 (50)	15 (41.7)	64 (43.2)	0.3
5 years	12 (30)	14 (6.8)	0 (0)	11 (45.8)	37 (5.9)	0.5

Abbrev.; CT; chemotherapy, RT: radiotherapy

No statistically significant difference was found between the patients who did not develop recurrence or metastasis and those who developed one of these.

When the survival rates of 40 patients who underwent extended resection were examined, the survival rates of 30 days, one, two, three, four, and five years were found 100%, 62.5%, 50%, 36.1%, 32.4%, 32%, respectively. Two of the patients (1%) underwent pneumonectomy due to synchronous tumor. One of the two patients was lost within the first 3 years while the other patient was lost in the fourth year.

The tumor size of 191 of 192 patients could be measured in the pathology laboratory and 77.0% of them (n = 147) were over 30 mm and 23.0% of them (n = 44) were 30 mm and below. There was no significant difference between these two groups in terms of the survival rates according to 30-day, 1-year, 2-year, 3-year, 4-year and 5-year. (p = 0.3, p = 0.8, p = 0.3, p = 0.5, p = 0.6, p = 0.5, respectively).

No statistically significant difference was found between sexes in terms of sex-specific survival (Figure 1).

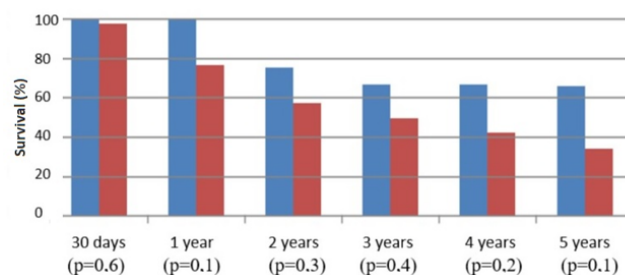


Figure 1. Survival by sex (female, male).

According to the history of smoking, there was no significant difference between the groups in the 30-day, 1-year, 2-year, 3-year, 4-year and 5-year survival of the four groups (p values are p = 0.8, p = 0.5, p = 0.1, p = 0.2, p = 0.7, p = 0.1, respectively).

Relation between the status of bronchial surgical margin and recurrence, metastasis, and secondary primer is shown in Table 5.

Table 5. The relation of the bronchial surgical margin with recurrence/metastasis.

	No recurrence/ metastasis (%)	Metastasis (%)	Recurrence (%)	Second primer (%)	Total (%)
Negative bronchial margin	147 (94.2)	15 (100)	19 (95)	1 (100)	182 (94.8)
Positive bronchial margin	9 (5.8)	0 (0)	1 (5)	0 (0)	10 (5.2)
Total	156 (81.3)	15 (7.8)	20 (10.4)	1 (0.5)	192 (100)

While complications did not develop in 84.6% (n = 154) of patients with bronchial surgical margin negative (n = 182), bleeding in 2.2% (n = 4), empyema in 1.1% (n = 2), fistula in 4.4% (n = 8), fistula in 3.8% (n = 2) wound infections, 0.5% (n = 1) bleeding and fistula, 0.5% (n = 1) tracheoesophageal fistula, 1%, empyema and wound infections in 1 (n = 2), empyema and bleeding in 0.5% (n = 1) developed (p = 0.6).

In comorbidity rating, zero points in 64.1% (n = 123), 1 point in 24.0% (n = 46), 2 points in 9.4% (n = 18) and 3 points in 2.6% (n = 5) were scored. When the

comorbidity scores were taken into consideration, there was no significant difference between groups.

In terms of the distribution of patients according to their stages, 8.3% (n = 16) of patients (n = 16) were stage 1a, 13.0% (n = 25) were stage 1b, 23.4% (n = 45) were stage 2a and 18%, 8 (n = 36) stage 2b, 34.4% (n = 66) stage 3a and 2.1% (n = 4) stage 3b. There was no statistically significant difference between the groups in the 30-day, 1-year, 3-year and 5-year survivals, whereas the 2-year survival (p = 0.05) and 4-year survival (p = 0.04) were significantly different between the groups (Table 6).

Table 6. Survival evaluation according to the stage.

Stage	1a n=16	1b n=25	2a n=45	2b n=36	3a n=66	3b n=4	Total n=192	P
30 days	14	25	44	35	65	4	187	0.2
1 year	13	21	40	25	48	2	149	0.1
2 years	8	14	33	21	35	0	111	0.05
3 years	5	9	24	18	27	0	83	0.1
4 years	5	3	20	15	21	0	64	0.04
5 years	3	1	10	9	14	0	37	0.3

In this study, there are stage 1 non-small cell lung cancer patients who performed pneumonectomy because of the localization, intraoperative complication, and accompanied benign status. Despite the histopathological diagnosis was carcinoid in three patients, we performed pneumonectomy due to the main bronchial localization that results in destroyed lung.

When the lymph node involvement of the patients (n = 192) was examined 42.7% (n = 82) were detected as N0, 41.7% (n = 80) as N1 and 15.6% as N2 (n = 30). There was a significant difference between the groups at 1 year, 2 years, 3 years, 4 years and 5 years survival when no difference was detected between the groups in the first 30 days survival.

Metastasis was detected in 7.3% (n = 6) of patients with N0 (n = 82), recurrence was found in 8.5% (n = 7) and second primer was detected in 1.2% (n = 1). Metastasis in 7.5% (n = 6) of patients with N1 (n = 80) and recurrence in 10% (n = 8). Metastasis in 10% (n = 3) of patients with N2 (n = 30) and recurrence in 16.7% (n = 5) were found (p = 0.7).

75% of all patients (n = 144) did not have any early or late complications. Bleeding in 4 patients (2.1%), empyema in 2 patients (1.0%), fistula in 8 patients (4.2%), fistula and empyema in 9 patients, 4.7% (0.5%) bleeding and fistula in 1 patient (0.5%), tracheoesophageal fistula in 1 patient (0.5%), empyema and wound infection in 2 patients (1.0%), empyema bleeding was seen. The 30-day, 1-year, 2-year, 3-year, 4-year, and 5-year survival rates of patients with complications were significantly different only in the first 30-day survival (p = 0.0001).

Discussion

Lung cancer is one of the most common causes of death in males and females. Non-small cell lung cancer constitutes more than 80% of all lung cancers [4]. Treatment of early stage non-small cell lung cancer is surgery, while advanced stage and when surgery is not possible non-surgical treatment is in the form of chemotherapy and radiotherapy [5]. The most important factor determining the prognosis is the tumor's stage [6]. The early diagnosis affects the survival of the patient positively [7].

Pneumonectomy for surgical treatment in lung cancer is a form of treatment that is characterized by itself and possible complications increase morbidity and mortality significantly [8].

We retrospectively evaluated 192 patients in our study. The patients were scattered around the age of 60 years. The proportion of male patients is higher than that of female patients.

When the patients were evaluated for 30-day, 1-year, 2-year, 3-year, 4-year and 5-year survival rates, 97.4%, 77.6%, 57.8%, 50%, 43.2% and 35.9% was calculated. In the literature, the early mortality rate was 4.6% and a 5-year survival rate of 27-30% has been reported [9].

When the survival of patients who received chemotherapy, radiotherapy, chemoradiotherapy and did not receive treatment was evaluated, 30-day survival was found to be statistically significant, but additional treatment protocols were applied after 3 weeks postoperatively in a majority of patients, so the effect of chemotherapy, radiotherapy or chemoradiotherapy on survival is controversial. Postoperative chemotherapy and radiotherapy are indicated for survival benefit in the literature [10,11]. When the treatment of patients is being regulated, many factors such as stage and performance are taken into consideration, so that the patient groups show differences within themselves.

In our study, left pneumonectomy was applied to 71.4% (n = 137) of 192 patients and this rate was similar to the literature [12]. There was no significant difference in survival according to the patients' operation sides. However, the right pneumonectomy mortality is higher in the literature [13].

The 5-year survival rate of the patients without recurrence, metastasis, and second primer was 38.4% while metastasis was 16.7%, recurrence was 20% and the second primer was 100% (p = 0.2). These rates are compatible with the literature [14].

Postoperative pulmonary complications have been reported to increase mortality risk [15]. The 5-year survival rate of patients with complications in our study was found to be below.

There was no significant difference between groups according to cell type at 5 years survival (p = 0.09) but the distribution and survival rates of histopathological types are similar when compared with the literature and squamous cell carcinoma is the most common type [16].

When 5-year survival was evaluated according to the postoperative stages of the patients, stage 1a was 50%, stage 1b 10%, stage 2a 43.5%, stage 2b 39.1%, stage 3a

36.8% and stage 3b 0% ($p = 0.3$). The rate of stage 3 patients was the most common stage, similar to the literature [9]. In a four-year survival analysis, 43.2% ($n = 64$) of patients survived ($n = 148$) ($p = 0.04$). 50% of patients ($n = 166$) survived over 3 years ($n = 83$) ($p = 0.1$). The relationship between stage and 2-year survival was significant ($p = 0.05$). In the literature, the survival rates of early stage lung carcinomas are quite high and there is an inverse relationship between stage and survival [17].

Survival evaluations can lead to differences in the number of patients at each time slot. This can be explained by the fact that each patient did not complete the five-year postoperative period.

Postoperative complications should be considered when evaluating stage and survival; because the evaluation of survival in early stage and advanced stage patients with complications is different. Comorbidity and performance status should be evaluated together with the stage of the disease. In our study, survival was assessed according to comorbidity of the patients but it was not statistically significant ($p = 0.8$). The literature has examined the effects of additional diseases and conditions accompanying lung cancer on survival and found no adverse effect on the survival of all [18].

Cigarette smoking, history of respiratory tract benign and malignant diseases, medications, respiratory function status, and the experience and physical conditions of the operating center can also have important effects on survival. When all these factors are evaluated together with the stage, the survival rates may change.

The role of cigarette in lung cancer etiology is known. In our study, the survival benefit of patients was studied by considering the use of 20 cigarettes a year. The 5-year survival rate (45.5%) of the non-smoking patients was found to be higher than that of the current smokers and who quit smoke, as in the literature ($p = 0.1$) [19].

When the five-year survival rate of 40 patients who underwent extended pneumonectomy was examined, it was observed that mortality was higher than classical pneumonectomy ($p = 0.6$) [20].

There was no significant result in 5-year survival assessed by considering only the tumor size ($p = 0.5$). Tumor diameter and survival are inversely proportional in the literature [22].

In our study, no significant difference was found be-

tween bronchial surgical margin and survival ($p = 0.3$). Recurrence was seen in 10% ($n = 1$) of patients with bronchial surgical margin positive ($n = 10$) ($p = 0.8$). In the literature, the recurrence rate increases up to 60% in microscopic bronchial surgery border positivity after lung resections [22]. Complications developed in 2 (20%) of 10 bronchial surgical borderline positive patients ($p = 0.6$). Postoperative complications have been reported in the literature in bronchial surgical borderline positive resections [23].

When we evaluate the histopathologic type of tumor together with stage, it should be kept in mind that each cell type may give different survival rates at different stages. In our study, survival rates according to cell type were calculated according to time intervals, but cell type and stage relation were not evaluated. When recurrence and metastasis rates were evaluated according to histopathological types, metastasis and recurrence were found in 23.5% and 17.6% of adenocarcinomas. The 50% metastasis rate in the atypical carcinoid group is not statistically significant because of the limited number of patients. It has been reported in the literature that the recurrence rate in non-squamous carcinomas is higher than squamous cell type [24].

In the literature, it is mentioned that recurrence and metastasis rates are higher in N2 than N1 and are also higher in N1 than N0. In our study, 5 year survival according to lymph node involvement was found to be significantly same as with the literature ($p = 0.002$) [25].

There are some limitations of this study. This study was a retrospective analysis and has a small sample size. Other limitations of this study that it consider parameters like survival, complication, recurrence and metastasis for just over 5 years. To have a deeper understanding of long-term results, patients should be monitored longer. Besides, other outcomes such as quality of life should be considered.

In conclusion, the improvement in patient care services and medical technologies reduced the morbidity and mortality rate in pneumonectomy patients to an acceptable level. Pneumonectomy still is an effective surgical treatment for selected patients in lung cancer.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

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Original Article

Comparison of anthropometric measurements and pectus index for chest wall deformities

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ABSTRACT

Background: Pectus excavatum (PE) is the most commonly seen chest wall deformity of childhood age. One of the most widely accepted methods in preoperative patient evaluation is the pectus index. In this study, it is aimed to measure the depth perception which is not aesthetic; aimed to establish an objective criteria which is simple, cheap, effective, and can be measured with physical examination or anthropometry instead of radiological examination dependent measurements.

Materials and Methods: 18 patients who were admitted to our clinic between May 2015 and August 2016 with complaints of PE deformity and who were planned for surgical repair were included in the study. Sternal deformity's depth, anthropometric measurements, pectus indexes, echocardiography, and pulmonary function test results and patient symptoms were classified.

Results: 18 patients were included in the study. The mean patient age was 14.27 years. One patient had mild mitral insufficiency and a flappy mitral front leaflet. One patient had mitral valve prolapse. No restrictive or obstructive results were observed in the pulmonary function test. There was no significant differences between the pectus index and sternal depth.

Conclusions: According to this study, there is a surgical indication in patients whose sternal depth is 1.2 cm and higher, regardless of the pectus index.

Keywords: depth perception, pectus excavatum, sternum

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Doi: 10.26663/cts.2020.00015

Received 04.12.2019 accepted 13.02.2020

This study was presented as oral presentation in 18th CWIG (Chest Wall International Group) Annual Meeting, June 14-16, 2017, Florence, Italy.

Introduction

The normally accepted body build involves a long chest wall and low anteroposterior depth in tall and slender people and deeper anteroposterior depth in short and bulky people. The replacement of cylindrical structures observed during childhood with the expansion of the chest in the transverse plane as age progresses is considered normal [1]. All other body build types are considered thoracic wall deformities.

There are various types of thoracic wall deformities, including the absence of one or more ribs, shortness of ribs, bifurcation of ribs, bridging, or posterior fusions of ribs, pectus excavatum (PE), pectus carinatum, sternal cleft, ectopia cordis, and Poland syndrome [2].

PE is a congenital chest wall deformity that presents with posterior depression of the middle and lower one-third of the sternum and posterior curvature of the costal cartilages [3].

Patients may be asymptomatic or may present with esthetic concerns as well as exertional dyspnea, dyspnea at rest, chest pain, and palpitation [4].

Various methods have been proposed for the evaluation and classification of these deformities. Thirty-two indexes have been defined for the degree of PE, treatment planning, and postoperative evaluation [5]. However, the pectus index is the most preferred and is included in the Kelly criterion.

This study aimed to determine whether the decision to perform surgery could be made by conducting a physical examination to quantitatively determine non-esthetic sternal depth measurements for pectus excavatum.

Materials and Methods

This prospective, case-control study was approved by the ethics committee for non-interventional clinical research of the Selçuk University Faculty of Medicine (approval number, 2015/222). Verbal and written informed consents were obtained from all patients. Further, this study was designed in accordance with the principles of the Declaration of Helsinki.

The study included total 18 patients who were admitted to the Department of thoracic surgery of the Selçuk

University Faculty of Medicine between May 2015 and August 2016 with complaints of PE deformity, who had no history of surgery due to PE, and who were examined by two thoracic surgeons and advised to undergo minimally invasive PE repair owing to a diagnosis of moderate-to-severe PE. Those patients who were not indicated for surgery, those who had previously undergone PE repair, and those with mild PE revealed upon physical examination were excluded from the study. Mild PE was evaluated based on the definition of the moderate and non-severe group of patients who did not require surgical intervention and could be treated using physical therapy or vacuum treatment [6].

Examinations

All patients underwent non-contrast computed tomography (NCTT). The pectus index was calculated using computed tomography. The ratio of the horizontally longest distance through the rib cage to the distance between the sternum and vertebrae at the deepest point of the PE in the axial section of the NCTT was used to calculate the pectus index. We also calculated the sternal depression index using computed tomography. This index was obtained by calculating the ratio of the maximum internal sagittal diameter of the left hemithorax to the distance between the anterior wall of the vertebral column and the posterior margin of the deepest part of the sternum [5].

The patients were enquired regarding any cardio-pulmonary complaints they may have had during their initial visits. Pulmonary function test (PFT) and echocardiography (ECHO) were performed for all patients. Besides, the presence of pathologies due to PE in ECHO and PFT was also assessed.

Anthropometric measurements

The parameters measured were as follows:

- Depth of the pectus deformity at the most collapsed area in the sternum (Figure 1a),
- Depth of chest cavity (Figure 1b),
- Lateral diameter of the chest (Figure 1c),
- Distance between two arcus costarum (Figure 1d),
- Chest circumference (Figure 2a),

- Distance between two shoulders (Figure 2b),
- Shoulder circumference (Figure 2c),
- Anthropometric index (the ratio of the depth of deformity in the sternum to the anterior–posterior distance of the rib cage).

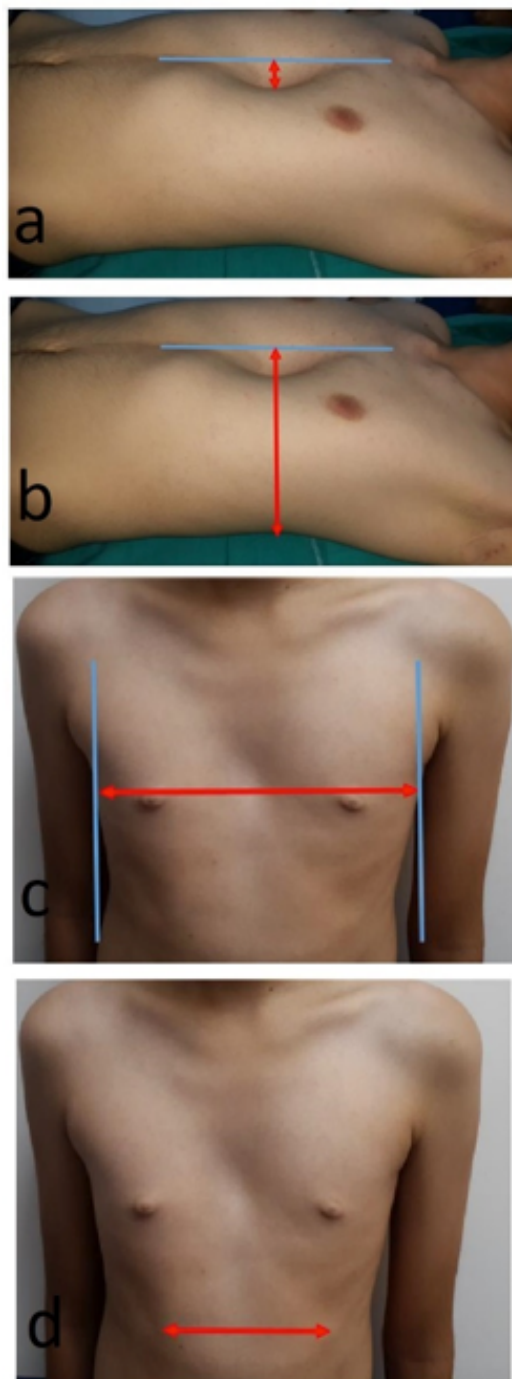


Figure 1. (a) Depth of the pectus deformity at the most collapsed area in the sternum, (b) depth of chest cavity, (c) lateral diameter of the chest, (d) distance between two arcus costarum.

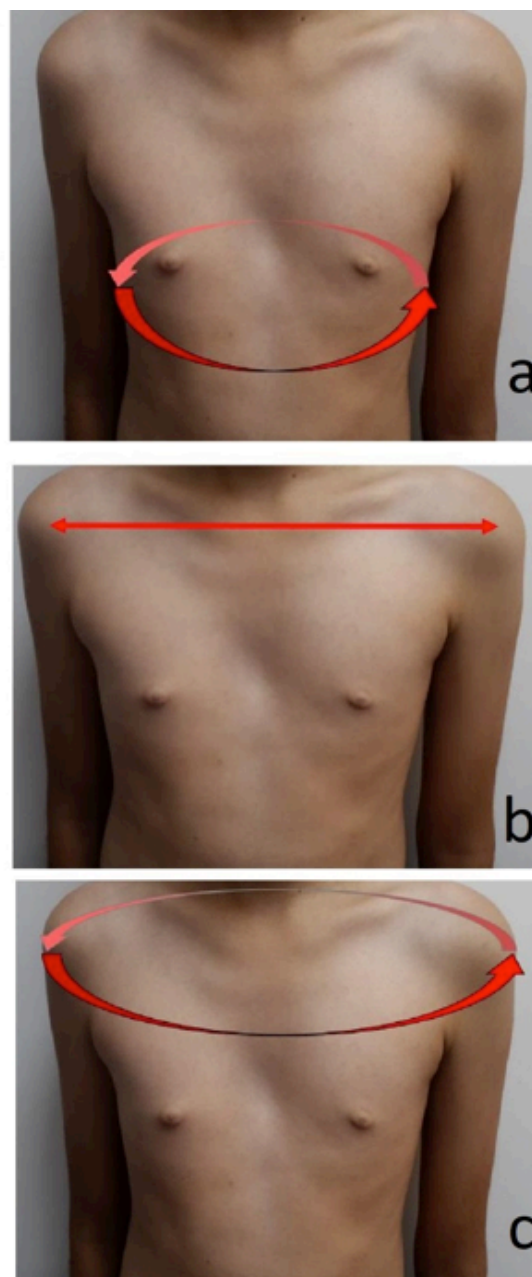


Figure 2. (a) Chest circumference, (b) distance between two shoulders, (c) shoulder circumference.

Threshold and Statistical Analysis

The anthropometric index, sternal depression index, anthropometric distances, and pectus index of the patients with PE deformities were statistically measured and compared.

Based on the sternal depression index, the severity of the PE deformity was considered mild when the index was <2.4 , moderate when the index was $2.4 - 2.9$, and severe when the index was >2.9 .

Those patients with a pectus index >3.25 , which is the limit value according to the Kelly criteria, were

grouped as having a positive pectus index PI (+), whereas those with a pectus index <3.25 were grouped as having a negative pectus index PI (-).

Homogeneity tests were performed, and both groups were compared using student's t-test. The statistical package for the social sciences (SPSS) software v.16.0 was used for statistical analysis.

Results

Total of 18 patients (5 females and 13 males) were included in the study. The mean patient age was 14.27 (7-24) years.

Measurement results by conventional indices

The mean pectus index of all patients was 3.51 (range, 2.22 - 4.80). Of the 18 patients included in the study, 9 were PI (+) and 9 others were PI (-). The mean pectus

index of the patients in the PI (+) group was 4.19 (range, 3.50 - 4.80), whereas that of the patients in the PI (-) group was 2.84 (2.22 - 3.17).

The total number of patients with mild PE based on the sternal depression index was 13. Based on this index, four patients had moderate PE and one had a severe deformity. The mean sternal depression index of all patients was 2.09 (range, 1.50 - 2.91).

The mean anthropometric index of all patients was 0.13 (range, 0.07 - 0.29).

The mean depth measurement of all patients was 2.2 (range, 1 - 3.5) cm. The mean depth of the patients in the PI (+) group was 2.28 (range, 1 - 3.5) cm, whereas that of the patients in the PI (-) group was 2.11 (range, 1.2 - 3) cm (Tables 1, 2).

Table 1. Demographic characteristics and index results of the patients included in the study.

Patients (n=18)	Age (mean=14.27)	Gender (F/M)	Pectus (Haller) index	Sternal depression index	Anthropometric index	Depth measurement (cm)	Pectus index group
1	16	M	3.50	1.97	0.07	1	PI (+)
2	18	M	2.50	1.77	0.15	3	PI (-)
3	11	F	3.96	2.16	0.13	1.5	PI (+)
4	11	M	3.96	1.58	0.08	1.2	PI (+)
5	9	M	2.22	1.50	0.08	1.2	PI (-)
6	18	F	3.08	1.82	0.07	1.4	PI (-)
7	14	M	3.09	1.85	0.08	1.4	PI (-)
8	22	M	4.50	2.72	0.29	3,5	PI (+)
9	10	F	4.44	2.91	0.15	2.4	PI (+)
10	14	M	3.17	2.03	0.12	2,5	PI (-)
11	16	M	4.80	2.60	0.17	3	PI (+)
12	9	F	4.37	2.50	0.16	2	PI (+)
13	7	M	2.77	1.90	0.11	1,7	PI (-)
14	13	M	2.69	1.69	0.17	3	PI (-)
15	13	M	3.08	1.99	0.20	3	PI (-)
16	15	F	4.33	2.39	0.14	2,5	PI (+)
17	17	M	3.87	2.52	0.20	3,5	PI (+)
18	24	M	2.97	1.76	0.11	1,8	PI (-)

Table 2. The means of PI (+) and PI (-) groups and all patients according to various indices.

	PI (mean)	SDI (mean)	AI (mean)	Depth (mean)
PI (+)	4.19	2.37	0.15	2.28 cm
PI (-)	2.84	1.81	0.12	2.11 cm
All patients	3.51	2.09	0.13	2.2 cm

Abbrev.; PI: pectus index, SDI: sternal depression index, AI: anthropometric index.

Anthropometric measurement results

The mean shoulder circumference of all patients was 80.83 (range, 61 - 102) cm. The mean distance between the two shoulders of all patients was 28.61 (range, 16 - 38) cm.

The mean distance between the two arcus costarum of all patients was 12.16 (range, 5 - 22) cm. The mean

chest circumference of all patients was 73.61 (range, 60 - 96) cm. The mean lateral diameter of the chest of all patients was 24.94 (range, 12 - 31) cm.

The mean distance between the anterior-posterior thoracic diameter of all patients was 15.88 (range, 11 - 20) cm. (Table 3).

Table 3. Mean values of anthropometric measurements of the PI (+) and PI (-) groups and all patients.

	Shoulder	Shoulder circumference	Arcus	Chest	Lateral	AP
PI (+)	29.22 cm	79.33 cm	12.11 cm	70.89 cm	22.78 cm	14.56 cm
PI (-)	28 cm	82.33 cm	12.22 cm	76.33 cm	27.11 cm	17.22 cm
All patients	28.61 cm	80.83 cm	12.16 cm	73.61 cm	24.94 cm	15.88 cm

Abbrev.; Shoulder: the distance between shoulders, the circumference of shoulders, Arcus: the distance between arcus costarum, Chest: chest circumference, Lateral: lateral diameter of chest, AP: anterior-posterior diameter of the chest.

Cardiopulmonary results

One patient experienced pain and constriction, another patient experienced only constriction. The remaining 16 patients did not experience any cardiac or pulmonary issues or discomfort. Echocardiography results were completely normal in 16 of the 18 patients (88.8%). One patient had mild mitral insufficiency and a flappy mitral front leaflet. One patient had mitral valve prolapse (MVP). No restrictive or obstructive results were observed in PFT.

Statistical results

The variance homogeneity test results of the groups with positive and negative pectus indexes were statistically significant for all variables. The Levene's test for equality of variances values was all greater than the p value (0.05). In other words, the variances of all the variables were equal, and the independent sample t-test (Student's t-test), which is a paired comparison test, could be applied. When the groups with positive and negative pectus indexes were compared, a statistically significant difference was observed between the groups in terms of the mean sternal depression index, mean lateral diameter of the chest, and mean distance between the anterior-posterior thoracic diameter ($p < 0.05$). No statistically significant difference was observed between the groups in terms of the anthropometric index, depth, shoulder circumference, the distance between two shoulders, the distance between two arcus costarum, and mean chest circumference ($p > 0.05$) (Table 4).

Table 4. Statistical evaluation of the mean of anthropometric measurement parameters.

		Mean	p
Sternal depression index	PI (+)	2.37	0.001*
Anthropometric index	PI (+)	0.15	0.224
Depth	PI (+)	2.28	0.665
Shoulder circumference	PI (+)	79.33	0.635
Distance between shoulders	PI (+)	29.22	0.699
Distance between two arcus	PI (+)	12.11	0.950
Chest circumference	PI (+)	70.89	0.300
Lateral diameter of the chest	PI (+)	22.78	0.041*
Anterior-posterior diameter of the thorax	PI (+)	14.56	0.021*

Statistically significance is shown by*

Discussion

The PE is the most common congenital chest wall deformity observed during childhood, and it is more common in men with a ratio of 3 - 9:1 [7,8]. Of the 18 patients, 5 were female and 13 were male. With a ratio of 3:1, the ratio of females in our study was lower than that reported in the literature but somewhat similar.

The pectus index, which defines the relationship between thoracic height and diameter, was defined by Haller in 1987. The index was used as a decision-making tool for managing PE. The pectus index is measured using thorax computed tomography of the axial section at the section with the maximum deformity of the thorax [9].

The generally accepted Kelly criteria for surgery indication are as follows: 1; progressive and symptomatic

PE deformities, 2; restrictive and/or obstructive disease indicated by the PFT, 3; cardiac compression or displacement, atelectasis in the lung, and a pectus index ≥ 3.25 based on computed tomography 4; cardiac anomalies, such as MVP or branch block, and 5; recurrent PE after unsuccessful repair [10,11].

In the literature, severely decreased lung function and vital capacity have been defined in patients with a pectus index >3.6 [12]. In the present study, 8 patients had a pectus index >3.6 , and their PFT results were normal. Further, the ECHO results of 7 of the 8 patients with a pectus index >3.6 were completely normal. In terms of cardiac results, our study is consistent with the reported literature. Seven of out 8 patients who were admitted to our clinic with esthetic concerns were described as “operable” by the clinician.

Glinkowski et al emphasized that physiological and cosmetic indications for surgical treatment of PE have become more prominent, and they attributed it to the development of minimally invasive surgical techniques [13]. This study is one of the several studies associating PE surgeries to esthetic reasons. In our study, we observed that the concept of depth that appears to the eye as “deep” was ≥ 1 cm. The smallest depth criterion in the study, i.e., 1 cm, was observed in one patient, and the pathology in this patient was detected via ECHO. Of the 17 patients admitted to the clinic with a depth of ≥ 1.2 cm, 88.2% had only depth complaints and 82.3% had no findings on ECHO or PFT. Only 2 of the 18 patients had cardiopulmonary complaints. The sternal depth of these patients was measured as 1.8 and 3 cm. These results indicate that the patients’ complaints are mostly associated with depth or hollowness. All these data suggest that esthetic reasons may be a new indication for surgery in patients with a depth of ≥ 1.2 cm who present only with sternal depression complaints.

The sternal depression index, a method defined in the literature, is used for classifying the pectus severity. The sternal depression index is the ratio of the maximal sagittal height of the left hemithorax to the minimum distance between the posterior wall of the sternum and the vertebral anterior surface of the same section at the point where the sternum is the narrowest. This index measures sternal depression, i.e., the severity of the PE.

It is defined as mild PE if the ratio <2.4 , moderate PE if it is between 2.4 - 2.9, and as severe PE if it is >2.9 [5].

According to this classification, 13 patients had mild, 4 had moderate, and 1 had a severe deformity. We also found that 72.2% of the patients for whom pectus deformity was planned to be corrected had a mild deformity. This high rate indicates that there exist indications other than the sternal depression index that drive both the patient and clinician to surgery. One interpretation regarding this study suggests that the primary indication is “esthetic concerns of the patient” and the conclusion of the clinician regarding “the presence of PE.” However, this evaluation may not be possible only by assessing the sternal depression index.

In this study, the mean sternal depression indexes in the PI (+) and (–) groups were 2.37 and 1.81, respectively, and the difference was statistically significant ($p = 0.001$). This difference indicates that the sternal depression index is correlated with the widely used pectus index, which is based on the Kelly criteria. However, the fact that the mean sternal depression index of all patients was <2.4 suggests that the positivity of the pectus index is not correlated with the severity of the PE. This signifies that if the severity of the PE is used in determining the indication for surgery, patients other than those with severe deformity can also be operated based on the patient’s complaints or clinician’s evaluation, even if the pectus index is greater than the threshold value.

Anthropometric measurements are important for the accurate documentation and observation of patients. Štefánková et al reported that anthropometry offers applicable and noninvasive methods for the evaluation of the PE and emphasized that these methods should be performed before performing CT [14]. The anthropometric index is a proportional value calculated through anthropometric measurements. It has been included in our study because it is an index that is based on the idea that an inexpensive and effective method, which is easy to learn and apply, may replace conventional methods. However, no statistically significant difference was observed between the patient groups with PI (+) and (–) in terms of anthropometric measurements of the distance between the two arcus costarum, chest circumference, distance between the shoulders, and shoulder circumfer-

ence. The reason for this result might be that age differences, muscle mass, and sex differences, and structural characteristics of patients might play an important role in the measurement of parameters related to body parts, such as shoulders and chest circumference. In terms of measurements of the anterior–posterior thoracic and lateral diameters of the chest, a statistically significant difference was found between patients with a positive and negative pectus index. No such studies have been reported yet; however, the differences between the two groups indicate that the measurement of these distances may be significant when deciding on surgery.

In this study, the depth of the deformity in the sternum was measured and the results were compared between the PI (+) and (–) groups in cm; however, no statistically significant difference was found. The threshold value of the anthropometric index is 0.12 [5,15]. In our study, the anthropometric indexes in the PI (+) and (–) groups were 0.15 and 0.12, respectively. Although no difference was observed between the two groups, the anthropometric and pectus indexes were correlated in terms of the threshold value. This signifies that a measure based on the metric measurements in the body correlates with the pectus index. This correlation is not surprising because the rationale behind this measurement is the ratio of the depth of the sternal deformity to the anterior–posterior thoracic diameter. A criterion that is correlated with the pectus index is more advantageous as it is easily applicable and does not require tomography. However, the subcutaneous thickness, body mass index, and weight of the patient are thought to play an effective role in this ratio. The significant difference between the two groups in the measurement of the anterior–posterior diameter of the thorax indicates that it is correlated with the calculation of this index.

The mean sternal depths in the PI (+) and (–) groups were 2.28 and 2.11, respectively, and the difference was not statistically significant. This result shows that the depth measurements between the PI (+) and PI (–) groups are not different. In the English literature, depth measurement in PE and the comparison of the pectus index have been very rarely reported. In the present study, the sternal depths were similar among patients who were admitted to our thoracic surgery outpatient clinic and indicated for surgery by the two clinicians.

The indication for surgery was based on the clinician's physical examination performed when the patient's complaint was noteworthy or when a significant level of depression was revealed in the physical examination; therefore, the level of sternal depression in the patients was measured in cm. In the present study, there was no difference in the PI (+) and (–) groups in terms of depth; this was interpreted as a confirmation that depth measurement was an indication for surgery regardless of the pectus index. In the literature, according to a survey conducted among thoracic surgeons, 40.7% of the surgeons reported that thoracic indexes were “rarely necessary” or “unnecessary.” Further, 13.6% of the surgeons stated that the pectus index was unnecessary and that 56.32% of the specialists stated that the threshold value of 3.25 was inaccurate for the pectus index [5]. These rates also indicate that thoracic surgeons use different criteria for surgical indications. Among the clinicians who determine the indication for surgery, a considerable number of specialists believe that the pectus index is unnecessary or the threshold value is inaccurate. In the present study, no association was observed between the pectus index and depth, and the use of the pectus index did not affect the indications for surgery and also showed that the requirement of thorax computed tomography is minimal.

Daunt et al reported that the vertebral level was not always the same in all the definitions of “the largest diameter” and “the height in the deepest place” used for calculating the pectus index [16]. Besides, Archer et al, through their study with 433 patients, reported that the diameter and height measurements at each vertebral level were different [9]. In the present study, we determined that the pectus index was correlated with neither the anthropometric indexes nor the patient's depth measurements.

Mortellaro et al reported that the pectus index was an important factor in determining the anatomical severity of the defect in the PE; however, it is still insufficient to predict the intraoperative and postoperative results [17]. Birkemeier et al reported that although measurement of the pectus index is the most widely accepted method, it showed different rates during expiration, inspiration, and relaxation in NCTT [18]. Accordingly, the pectus

index was found to be significantly lower during inspiration than during inspiration and relaxation. All these results affect the measurement of the pectus index and therefore the indication for surgery.

The limitation of our study is that it was a single-center study. Involving more number of patients might provide stronger and better results.

In conclusion, although the pectus index is a generally accepted method under the Kelly criteria for patients with PE in terms of determining the indications for surgery, the results of this study indicate that the pectus index does not correlate with the main complaints and symptoms of the patients. No association could be established between the pectus index and the clinician's decision for surgery after the clinical evaluation of a patient. The calculation of the pectus index via NCTT scans should not be mandatory in determining the operative criteria in patients with PE. In this context, the depth of the deformity as well as the depth of the anterior-posterior diameter and lateral diameter of the chest determined via metric measurements to be performed during clinical visits of the patients, will be effective in the decision for surgery. It is recommended that NCTT, which has disadvantages like radiation and cost, should not be used in patients unless deemed extremely essential, and patients should be evaluated using simple methods, such as two-way direct chest X-ray, echocardiography, PFTs, and sternal depth measurements.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

Acknowledgement

We would like to offer special thanks to deceased Assoc. Prof. Dr. Murat Oncel, although no longer with us, for his support and efforts.

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Original Article

Is ultrasonography helpful in minor trauma patients with rib fractures?

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ABSTRACT

Background: The most common injury associated with blunt thoracic trauma is the rib fracture. Outpatients, who had a minor blunt trauma that did not form any complications, present more than half of the rib fractures. Unfortunately, there are several limitations on the chest x-ray. In this study, we investigated the efficacy of ultrasonography in the diagnosis of rib fractures resulting from blunt thoracic trauma.

Materials and Methods: Fifty-eight patients who were admitted to the Thoracic Surgery Outpatient Clinic in our center due to minor thoracic trauma between October 2017 and July 2018 were included in the study. All patients underwent chest radiography, and thorax US after a detailed history and physical examination were performed.

Results: Of the 58 patients included in the study, 33 (56.9%) were male, and 25 (43.1%) were female, while the mean age was 46.79 ± 15.75 years. While the rib fractures were detected in 24 patients with chest x-ray, US detected rib fractures in 47 patients. The comparison between the two examinations, the superiority of the US in the diagnosis of rib fracture was statistically significant compared to the chest radiography ($p < 0.001$).

Conclusions: We believe that preferring ultrasound instead of thorax CT for its less radiation and lower cost at the next step beyond chest x-ray for patients, who applied to the outpatient clinic with minor trauma and whose general condition is well, is more beneficial.

Keywords: rib fracture, ultrasonography, chest x-ray

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Doi: 10.26663/cts.2020.00016

Received 13.11.2019 accepted 17.02.2020

This research was presented in the 21st Annual Congress of the Turkish Thoracic Society Antalya, Turkey on 11-15 April 2018.

Introduction

The most common injury associated with blunt thoracic trauma is the rib fracture [1,2]. More than half of rib fractures are presented by outpatients who had a minor blunt trauma that did not form any complications [3]. Rib fractures are clinically suspected in the presence of the related history of the patient, coughing, and localization of the pain with palpation and deep breathing [2]. Unfortunately, there are several limitations on the chest x-ray [4,5]. Costal cartilage fractures could be radiologically overlooked unless the densely calcified cartilage is broken [4]. Besides, obesity and co-existing lung conditions may adversely affect the quality of the radiography and may cause difficulty in interpreting and diagnosing the image [6]. Due to the adjacency of abdominal soft tissues in the lower rib fractures, it is difficult to interpret the radiograph [5]. Accurate identification of rib fractures with ultrasonography (US) in the presence of clinical suspicion usually does not significantly change the patient management, but in fact, leads to significant advantages in practice [7].

In this study, the efficacy of ultrasonography in the diagnosis of rib fractures resulting from blunt thoracic trauma was investigated.

Materials and Methods

Following institutional review board approval (1204/2019), fifty-eight patients who were admitted to the Thoracic Surgery Outpatient Clinic in our center due to minor thoracic trauma between October 2017 and July 2018 were included in the study. Minor traumas were evaluated as traumas there may be rib fractures without pneumothorax, hemothorax, or pulmonary contusion. All patients underwent chest radiography, and thorax US after a detailed history and physical examination were performed. An experienced radiologist performed the chest x-ray evaluation and ultrasonography, and a thoracic surgeon performed the clinical evaluation. Ultrasonography was performed on the same day after chest x-ray.

The chest x-ray (Samsung, GC80, Korea) was performed without a grid nearly 180 cm in posteroanterior position with a 85 kVp and 3.2 mAs. Ultrasonography was performed on patients by the radiologist using a 5-12 MHz linear array probe. Ultrasonography was performed longitudinally in such a way that the patient was in a lying or sitting position, starting from the place where the physical examination was most pain-

ful, including the adjacent ribs. During the ultrasound examination, cortical border irregularity, acoustic edge shadow, and local hematoma criteria were taken into consideration (Figure 1). Ultrasonography and chest radiography results were compared.

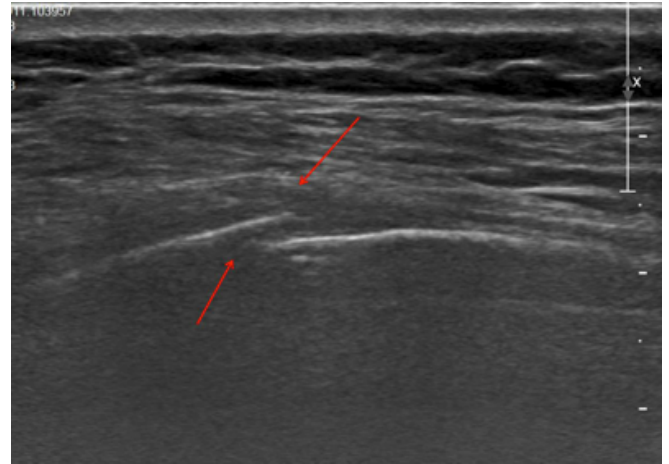


Figure 1. Rib fracture detection with the US.

Statistical Analysis

Data were analyzed retrospectively. The variables were reported as mean and standard deviation (SD) with a confidence interval (CI) of 95%. Mean values were compared with the Student's T-test and one-way analysis of variance (ANOVA). The ratios of categorical variables were given in percentages and compared with Fisher's Exact test or Pearson's chi-square test. In addition, sensitivity and specificity values are given as a result. The significance level was accepted as $p < 0.05$. All analyses were performed using SPSS 22.0 (SPSS Inc. Chicago, Illinois, USA) software.

Results

Of the 58 patients included in the study, 33 (56.9%) were male, and 25 (43.1%) were female, while the mean age was 46.8 ± 15.8 years. The reason for the reference to the outpatient clinic was falling for 49 patients (84.5%), traffic accidents for five patients (8.6%), and assault was four patients (6.9%). The patients were admitted to the outpatient clinic with an average of 4.3 (1-20) days after the trauma, while the application was on the 3rd day most frequently. The mean duration of the ultrasound examination was 10.36 ± 0.325 minutes. 31 patients had right-sided (53.5%), 26 patients had left-sided (44.8%) and one patient had bilateral (1.7%) pain (Table 1). The total number of fractures detected by chest x-ray was 37, and the total number of fractures detected by the US was 94.

Table 1. Characteristics of the study group.

	n=58
Age	46.8±15.78
Sex	
Male	33 (56.9%)
Female	25 (43.1%)
Side	
Right	31 (53.5%)
Left	26 (44.8%)
Bilateral	1 (1.7%)
Type of trauma	
Falling	49 (84.5%)
Traffic accident	5 (8.6%)
Assault	4 (6.9%)
Duration until Examination	4.36±0.53 days
US duration	10.36±0.325 min

While the rib fractures were detected in 24 patients with chest x-ray, US detected rib fractures in 47 patients. The total number of fractures detected by chest x-ray was 37, and the total number of fractures detected by the US was 94. As a result of the comparison between the two examinations, the superiority of the US in the diagnosis of rib fracture was statistically significant compared to the chest radiography ($p < 0,001$) (Table 2).

Table 2. Detection of the rib fracture.

	Chest x-ray (n=58)	Thorax US (n=58)	P
Rib fracture (+)	24 (41.4%)	47 (81%)	<0.001
Rib fracture (-)	34 (58.6%)	11 (19%)	

In the rib fracture diagnosis, the sensitivity of chest x-ray and US were 48.9% and 97.9%; specificity was 90.9% and 90.9%; positive predictive value (PPV) was 95.8% and 97.9%; negative predictive value (NPV) 29.4% and 90.9%; the accuracy rate was 56.9% and 96.6%, respectively (Table 3).

Table 3. Sensitivity, specificity, positive-negative predictive value and accuracy of ultrasound and chest radiography.

	Chest x-ray	USG
Sensitivity	48.9%	97.9%
Specificity	90.9%	90.9%
PPV	95.8%	97.9%
NPV	29.4%	90.9%
Accuracy	56.9%	94.8%

Abbrev.; PPV: Positive predictive value, NPV: negative predictive value

Discussion

The rib fractures are the most common thoracic injury. Fractures exist in only 32 - 42% of symptomatic patients [2,8]. The main symptom of rib fracture is the pain in the area of movement or the non-moving injury area [9]. Physical examination and chest x-ray are the initial diagnostic methods for the detection of rib fractures and are the main diagnostic tools [1,5]. The presence of crepitation in the physical examination may lead to the diagnosis, but this may not be the case for minor traumas. There are also several limitations in plain chest radiography [5]. In these patients, only 49% of rib fractures were detected by a precise physical evaluation and chest x-ray [1]. Obesity and co-existing lung disorders may adversely affect the quality of radiography, which is a challenge to interpret and diagnose the image [6]. Besides, some patients may not provide a suitable position during the plain radiography procedure and may cause limitations in the radiological examination [8]. Rib fractures could be detected in 50-80% of patients with minor chest trauma by conventional radiological examination for various reasons [8].

Ultrasound examination has become popular in recent years as a useful and non-invasive diagnostic tool [5]. There are studies in which ultrasonography has better results than chest x-ray in the diagnosis of rib fractures [4,6,10,11]. In a meta-analysis, the specificity and sensitivity of the US were reported to be better [12]. Studies are reporting that ultrasound is also useful in sternal fractures [13,14]. Chan reported that the US has higher accuracy in thoracic bone fractures [7]. The sensitivity, specificity, and efficacy values of ultrasound in the diagnosis of rib fracture were found to be better than chest radiography in our study in accordance with the literature. Our patients were admitted to the outpatient clinic an average of 4.3 days after trauma. Hwang et al reported that no significant effect on the results that duration time until the US examination [5].

Being non-invasive, portable, relatively inexpensive, non-radiation and reproducible are the most critical advantages of ultrasonography and these make ultrasonography a valuable diagnostic tool [1]. It is also a reliable diagnostic tool for pregnant patients [8]. A plain chest x-ray may overlook uncalcified rib fractures, especially in costal cartilages [3]. It is known that ultrasound is more sensitive than plain x-ray and tomography in such fractures [8]. Studies are showing that ultrasound

could better detect costal cartilage fractures and costochondral junction fractures [4,10]. Griffith et al [10] reported that plain chest radiography could detect rib fractures in 12% of patients with chest trauma, while ultrasonography could detect in 78% and ultrasonography was more sensitive. In our study, rib fracture was detected in 41.4% of patients with chest x-ray and 81% with the US. Martino et al [15] argued that ultrasonography is more useful in rib and costal cartilage fractures and should be performed in every patient with chest trauma as it could detect internal organ injuries.

Accurate identification of rib fractures by ultrasonography in case of clinical suspicion usually provides some advantages in practice, although it does not substantially alter patient management. First, with the early diagnosis of rib fractures, it might be necessary to initiate an appropriate pain management protocol that confirms the use of analgesic therapy or intercostal nerve blockages. Medical advice on employee return to work and activities is essential [7]. Meanwhile, the US is an easy, accessible, rapid, and accurate diagnostic procedure in hemodynamically unstable patients with hemothorax and/or pneumothorax [1]. The diagnosis of rib fracture is also important in terms of the medico-legal perspective [2,16]. The significant ultrasonography disadvantages are the difficulty in diagnosis in large-breasted patients, obesity, fractures in the ribs under the scapula, or the first rib fractures below the clavicle [1,5,8].

In conclusion, we believe that preferring ultrasound instead of thorax CT for its less radiation and lower cost at the next step beyond chest x-ray for patients, who applied to the outpatient clinic with minor trauma and whose general condition is well, is more beneficial. With more studies including more centers and the number of patients, ultrasonography would be used more widely as a result of supporting the effectiveness of ultrasonography in the diagnosis of rib fracture.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

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To cite this article: Öztürk Ö, Yıldız D, Acar A, Ceylan KC, Kaya ŞÖ, Cansun F. Intrapleural tranexamic acid in persistent malignant hemothorax: a case report. Curr Thorac Surg 2020;5(2):84-86.

Case Report

Intrapleural tranexamic acid in persistent malignant hemothorax: a case report

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ABSTRACT

Hemothorax occurs due to various conditions such as trauma, malignancy, tuberculosis, bullous lung disease, and lung abscess. In patients with malignant hemothorax, stabilization of the clinical condition and treatment of primary disease is of primary importance. A 53-year-old female patient, who had a history of surgery for ovarian cancer and liver metastasis, admitted to the hospital with complaints of shortness of breath. The patient was found to have pleural effusion on the right hemithorax, and a tube thoracostomy was performed. During the clinical follow-up, the amount of drainage did not decrease. Thereby, the patient underwent a video-thoroscopic evaluation, and chemical pleurodesis was applied intraoperatively. Despite chemical pleurodesis, hemorrhagic drainage continued. Intrapleural tranexamic acid administration was performed to ensure the stabilization of the clinical condition. Immediately days after the intrapleural application of tranexamic acid, the drainage of the fluid decreased and became sero-hemorrhagic. The management of this case made us think that intrapleural tranexamic acid may be an alternative in persistent malign hemothorax.

Keywords: tranexamic acid, malign effusion, pleura, hemothorax

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Doi: 10.26663/cts.2020.00017

Received 06.11.2019 accepted 06. 05.2020

Introduction

Hemothorax is diagnosed as when the hematocrit level in the pleural fluid is higher than 50% of blood hematocrit. Although the incidence is unknown, the most common cause is trauma [1]. Hemorrhagic effusions also might occur in malignancies, but malignancies rarely cause a massive hemothorax [2]. Malignant effusion was defined as malignant hemothorax with hemorrhagic drainage above 500 cc/day after the pleural malignancy was proven. The management of these patients can sometimes be extremely difficult. Herein, we present a massive malignant hemothorax that was controlled with intrapleural tranexamic acid (TXA).

Case Report

A 53-year-old female patient with no history of trauma or drug use presented with shortness of breath. She had a history of surgery for ovarian carcinoma eight years ago, and liver metastasis was detected four years after surgery. The chest x-ray revealed right-sided massive pleural effusion (Figure 1).



Figure 1. Chest x-ray showing massive pleural effusion.

Thoracentesis revealed a hemothorax, and a tube thoracostomy was performed. Approximately 800-1000 cc fluid per day was drained for five days. Within the follow-up period, the hemoglobin level was dropped to 7 gr/dL, hematocrit to 20%, and liver function tests minimally elevated. Thorax computed tomography demonstrated pleural thickening and loculated effusion (Figure 2).

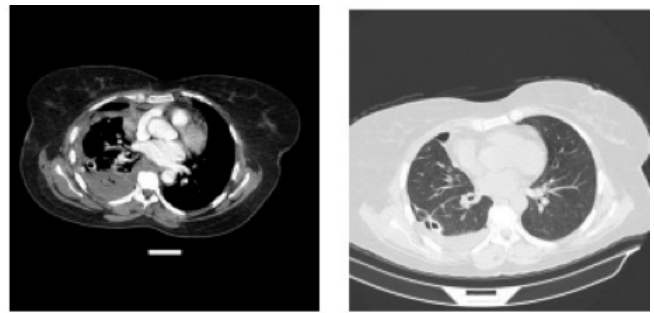


Figure 2. Preoperative thorax computed tomography findings.

The patient underwent a video-thoracoscopic exploration. Hemorrhagic areas spreading the whole pleura were observed. Pleural biopsies were taken, and the frozen section examination revealed pleural malignancy. Pleurodesis was performed with sterile talc insufflation. Definitive histopathologic and cytological examination of pleural fluid and specimens were reported as sarcomatoid carcinoma metastasis. During the postoperative period, since hemorrhagic drainage was continued, two units of packed red blood cells and fresh frozen plasma/day were transfused daily. The hemorrhagic drainage continued approximately 400 cc/day in the first postoperative week. Chest x-rays after the operation and after 2 weeks were demonstrated in Figure 3.

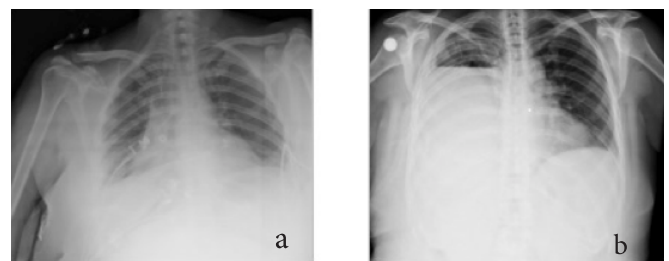


Figure 3. Chest X-ray immediately after the operation (a), chest X-ray after two weeks postoperatively (b).

Since the patient's general condition was gradually deteriorated, tranexamic acid (Transamine® %10 ampule, Istanbul) 5 g (50 mg/cc) was applied intrapleurally in 250 cc of an isotonic solution, and the chest tube was clamped for 2 hours. Then, the clamping was stopped, and the tube was allowed for free drainage. At the end of the third day, hemorrhagic drainage decreased to 200-300 cc/day and became sero-hemorrhagic. The pleural fluid examination revealed no hemothorax. The patient was referred to the oncology department after the clinical status was stabilized with tube thoracostomy.

Written informed consent was obtained from the patient for publication of her data.

Discussion

In patients with malignant pleural effusions, palliative therapies are preferred due to the lack of complete cure chance with surgical treatment and low life expectancy. In this regard, patients underwent repetitive thoracentesis, intrapleural catheter applications, pleurodesis, and palliative treatments [3]. The British Thoracic Society (BTS) recommends systemic chemotherapy in malignant effusions with asymptomatic and non-specific tumor-related malign effusions [4]. Hemothorax, due to malignancies, is very rare. In our case, the patient had no history of trauma, tuberculosis, or other situations such as lung abscess or bullous lung disease, which could explain the hemorrhagic nature of the pleural effusion. However, she was diagnosed with ovarian carcinoma and had liver metastasis in her history.

Schwannoma, thymic lesions, vascular tumors, germ cell tumors, hepatocellular carcinoma (HCC), lung cancer, mesothelioma, primitive neuroectodermal tumors may cause extramedullary hematopoiesis and are involved in the etiology of malignant hemothorax [4]. Tranexamic acid is an antifibrinolytic agent and reduces postoperative bleeding and transfusion risk in cardiothoracic surgery [5]. A synthetic lysine derives of tranexamic acid that binds to lysine binding sites in plasminogen inhibits plasmin activation. Plasmin cannot bind to fibrinogen or other monomers and inhibits fibrinolysis. It also preserves platelet function by inhibiting plasmin-dependent platelet activation. As a result, tranexamic acid prevents the breakdown of the existing clot and does not cause new clot formation.

Other than the hemothorax, the application of tranexamic acid appears in different local application areas in the literature. In patients with chronic inflammatory pleural/pulmonary disease undergoing open surgery intrapleural tranexamic acid administration has been reported to be useful and effective in bleeding control [5].

In the literature, combined oral and intrapleural tranexamic acid was given to two patients with pleural mesothelioma followed by hemothorax. It has been found to reduce the amount of bleeding and the need for transfusion [6]. In our case, both the pleural tissue and fluid were proven to be malignant. The drainage of the patient continued 800-1000 cc per day and the patient was diagnosed as malignant hemothorax.

Intrapleural tranexamic acid application is rarely practiced after pulmonary resections and decortication.

However, there are some reports that tranexamic acid may reduce the re-thoracotomy risk when used in these situations [7-8]. The use of intrapleural tranexamic acid in malignant hemothorax is even more uncommon.

In conclusion, in our case, intrapleural tranexamic acid was determined to relieve the malignant hemothorax and improve the patient's clinical condition since she did not respond to blood and fresh frozen plasma transfusions and the intraoperatively performed talc pleurodesis. Since the patient's primary treatment was chemotherapy and/or radiotherapy, the main objective should be stabilizing the clinical condition in malignant hemothorax to initiate the routine treatment of the primary disease. In this respect, intrapleural tranexamic acid administration was considered as an alternative method for patients.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support.

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To cite this article: Temiz S, Demir OF, Onal O, Hasdiraz L, Oguzkaya F. A case of relapsing polychondritis developing tracheomalacia. Curr Thorac Surg 2020; 5(2): 87-90.

Case Report

A case of relapsing polychondritis developing tracheomalacia

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ABSTRACT

There are limited data on the relapsing polychondritis (RP). RP is an uncommon autoimmune disorder that is characterized by recurrent inflammation and destruction of the cartilage and connective tissue in various parts of the body with a high risk of misdiagnosis. Here we present a rare case of a 43-year-old female with relapsing polychondritis with tracheal involvement.

Keywords: autoimmune disease, relapsing polychondritis, tracheomalacia

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Doi: 10.26663/cts.2020.00018

Received 04.005.2020 accepted 13.07.2020

Introduction

Relapsing polychondritis (RP) is a rare, autoimmune, multisystem disease characterized by antibodies to type II collagen in its pathogenesis, which is accompanied by episodic inflammatory attacks in articular and non-articular cartilage tissue [1,2]. Airway manifestations are the most common cause of morbidity and mortality in the disease [3].

Case Report

A 43-year-old female patient was admitted to our emergency department in 2015 with nausea, vomiting, and sudden respiratory distress. The patient with severe tachypnea and stridor revealed carbon dioxide (CO₂) retention and respiratory acidosis in the arterial blood gas. The patient, whose airway safety was at risk, was intubated under emergency conditions and admitted to the anesthesia intensive care unit. The patient who did not have a disease associated with lung parenchyma, which would lead to carbon dioxide retention. In the computed tomography of the thorax (CT) tracheal wall thickening and tracheal lumen narrowing were detected (Figure 1).

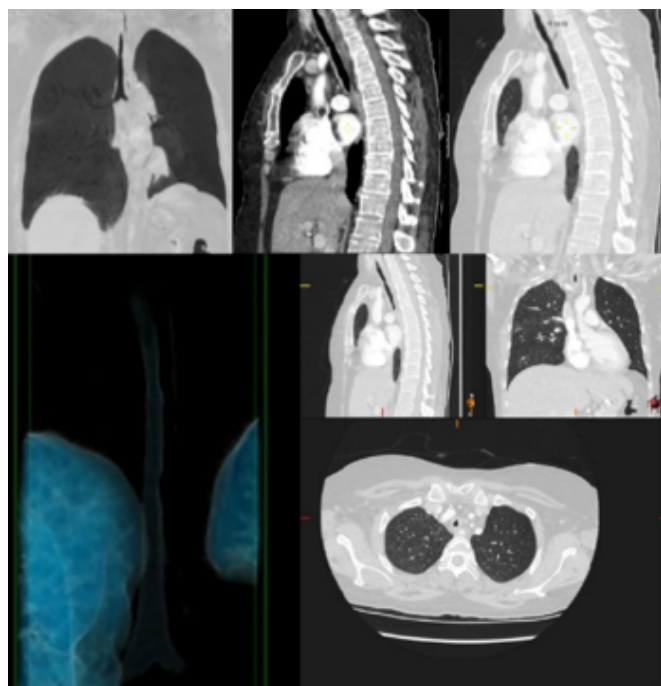


Figure 1. Thorax CT shows tracheal wall thickening and stenosis of the tracheal lumen.

It was understood from the hospital records that the patient was diagnosed with RP due to swelling and edema in her ear 2 years ago. In the thorax tomography taken at this date, there was no thickening and stenosis in the wall of the trachea (Figure 2).

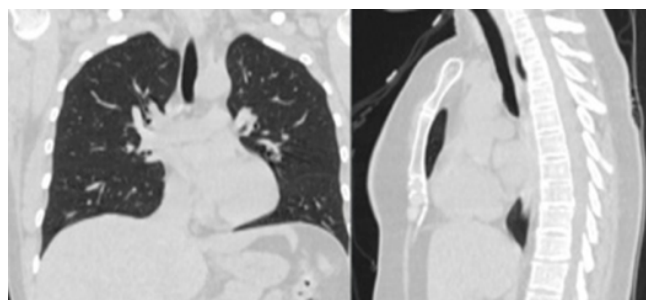


Figure 2. At the time of diagnosis of relapsing polychondritis (two years ago); trachea is normal in the thorax CT.

In PET/CT taken after thorax tomography, thick and asymmetric hyperdense views belonging to the tracheal walls, which did not show significant hypermetabolic activity, were detected (Figure 3).

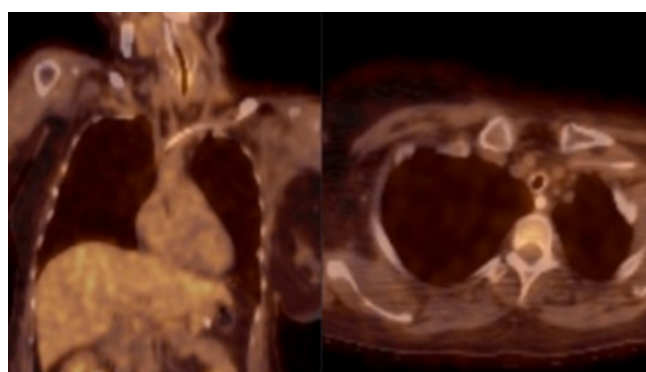


Figure 3. In F18-FDG PET-CT, it was interpreted as asymmetric hyperdense views of the trachea walls, which were not normal and showed significant hypermetabolic activity.

The patient was intervened with a rigid bronchoscope numbered 6.5. It was observed that the airways were hyperemic and edematous. No formation taking up endobronchial lesion was detected. However, during the maneuver with a rigid bronchoscope, the tracheal lumen was seen to collapse again. Tracheal stent implantation was planned for the patient whose extubation attempt was unsuccessful. During the stent application, the patient who developed CO₂ retention stent attempt to the patient failed. The patient was intubated and returned to the anesthesia intensive care unit. Upon widespread development of subcutaneous emphysema, control thorax and abdominal CT were taken. There was pneumothorax in the left hemithorax, widespread air was detected in the retroperitoneal region and abdomen (Figure 4).

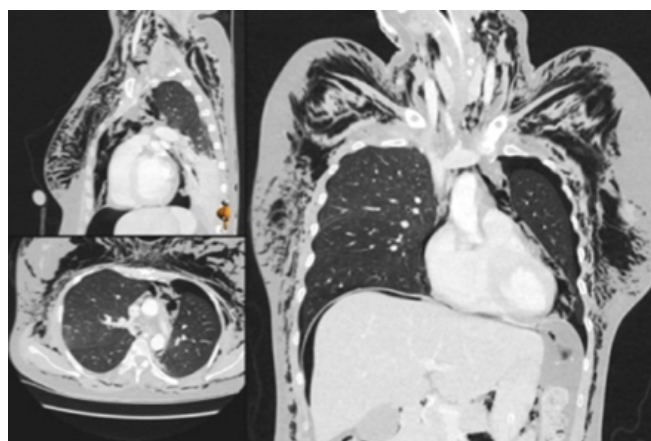


Figure 4. Thorax CT shows pneumothorax in left hemithorax, diffuse air in the retroperitoneal area and abdomen.

Tube thoracostomy was performed to the left hemithorax. The patient underwent laparoscopy and the air in the abdomen was drained, but no perforation was detected. After re-bronchoscopy, mucosal laceration was detected in the left main bronchus in an area of approximately 0.5 cm. The chest drain was removed on the 6th day after the procedure after the follow-up of the patient, due to the expansion of the chest x-ray and no air and fluid drainage from the chest tube. The patient, whose medical treatment is continued in the intensive care unit; On the 11th day after laparoscopy, pseudomonas aeruginosa growth in bronchoalveolar lavage (BAL) culture. The patient died on the 28th day due to uncontrolled infection due to sepsis.

Written informed consent was obtained from the patient for publication of her data.

Discussion

RP is a systemic disease causing inflammation of cartilaginous structure in multiple organs [4]. RP progresses as attacks. Our patient had three known attacks. Our patient had her first RP attack in 2013 with edema and swelling on the auricle. Edema develops in the airway during the active period of the disease, and fibrous tissue develops due to chronic inflammation in the late period and the airway collapses due to the destruction of the laryngotracheal cartilages [5]. The estimated incidence is 3.5/1,000,000/year [6]. Airway involvement is present in up to 50% of patients with RP and is a major cause of morbidity and mortality [7]. PET/CT is a potentially powerful tool for the early diagnosis of

RP, especially in patients without easily biopsied organ involvement [8]. This method also facilitates the evaluation of disease coverage and disease activity. PET/CT examinations performed in our patient were interpreted as thick and symmetrical hyperdense views belonging to the tracheal walls, which did not show significant hypermetabolic activity. Lung infections develop more frequently secondary to obstruction, which occurs as a result of infection and scarring [4]. In our patient who developed respiratory tract infection during follow-up in the intensive care unit, *Pseudomonas aeruginosa* was grown in the bronchoalveolar lavage taken during bronchoscopy. The patient died on the 28th day of her hospitalization due to sepsis.

In conclusion, relapsing polychondritis is a recurring inflammatory disorder of unknown etiology causing inflammatory reactions in the cartilaginous structures of the nose, ears, trachea, and the joints. Larynx, trachea, and bronchi are most frequently affected. Due to the rarity of the disease, there is no standardized treatment approach, and the treatment is guided by the clinical presentation and the severity of the disease [9]. The presented case was a patient who was diagnosed with relapsing polychondritis 2 years ago and developed tracheal involvement while under treatment, resulting in death. Detection of respiratory involvement at an early stage can significantly reduce mortality.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support.

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Case Report

A case report of congenital bronchial diverticulum and bronchogenic cyst presenting with a whistle

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ABSTRACT

Congenital diverticula of the left main bronchus are extremely rare in the adult. Bronchial diverticula could act as a reservoir for bronchial secretions and theoretically predispose to repeated respiratory infections. We reported a diverticulum originating from the left main bronchus with recurrent bronchopneumonia and whistling since 15 years of age. Additionally, our case had a paraaortic mediastinal bronchogenic cyst. Physical examination demonstrated whistling in the expiratory phase, which appeared when he was lying on his back or his left side. Flexible bronchoscopy showed a round-shaped lumen of the left main bronchus and bubbling from slits or indentations of the bronchial mucosa in the left main bronchus. Because our patient complained of whistling and history of recurrent bronchopneumonia infection due to bronchial diverticulum, he was operated. To the best of our knowledge, there has been no case of congenital bronchial diverticula localized in the left main bronchus associated with a paraaortic mediastinal bronchogenic cyst in the medical literature.

Keywords: bronchial diverticula, bronchogenic cyst, whistling

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Doi: 10.26663/cts.2020.00019

Received 10.04.2020 accepted 02.06.2020

Introduction

Diverticula of the main bronchus is a rare condition that was first described by Rocitansky in 1846 [1]. Diverticula of the main bronchus is usually asymptomatic and not a pathologic condition. However, in some cases, therapeutic interventions might be considered. Bronchogenic cysts are congenital lesions derived from abnormal budding of the embryonic foregut. The mediastinum or lung location of bronchogenic cysts are related to the time of separation from the tracheobronchial tree [2].

Here we encountered the case of an enlarged subcarinal air cyst accompanied by bronchial diverticula and paraaortic mediastinal bronchogenic cyst. This is the first case wherein the diagnosis and treatment of left main bronchial diverticula with the paraaortic mediastinal bronchogenic cyst is reported.

Case Report

The patient was a 20-years-old male. He had recurrent bronchopneumonia and whistling for 15 years of age. Whistling had occasionally occurred when he was in the recumbent position during sleep at night. There was no clubbing in the fingers and no complaints of dyspnea at rest or with slight effort. Physical examination demonstrated wheezing in the expiratory phase, which appeared when he was lying on his back or his left side. When the patient was admitted to the hospital, there was no bronchopneumonia. The patient did not have a smoking history. Pulmonary function test showed the following results; forced expiratory volume in 1 second (FEV1), 3.32 L and FEV1/FVC, 80%. Chest CT and MRI demonstrated an air cyst (size, 25 mm) connected to the lumen of the left main bronchus and paraaortic mediastinal bronchogenic cyst (Figures 1, 2).

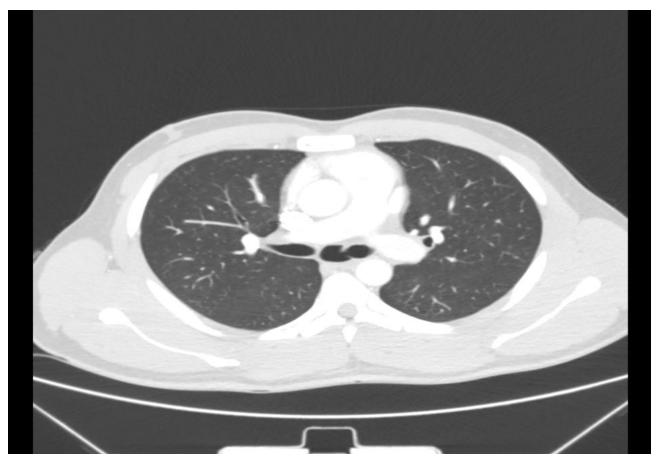


Figure 1. Computed tomography showing a connection between the subcarinal mediastinal air cyst and the left main bronchus.

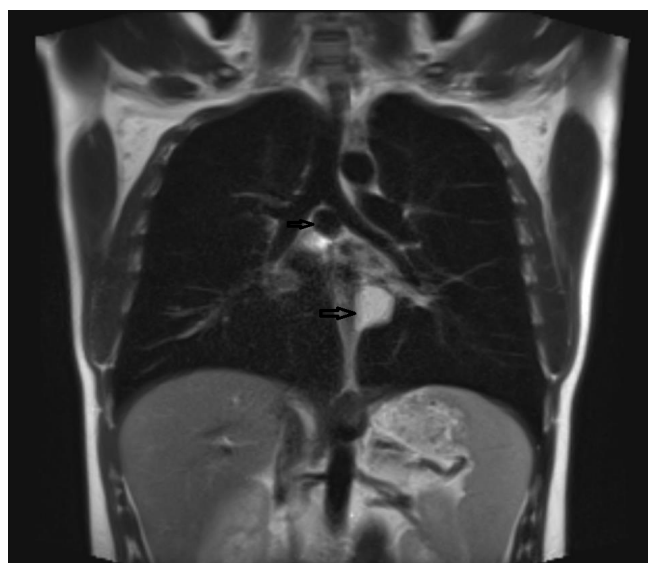


Figure 2. Magnetic resonance imaging in the frontal plane showing a subcarinal mediastinal air cyst and the paraaortic mediastinal bronchogenic cyst.

Flexible bronchoscopy showed a round-shaped lumen of the left main bronchus and bubbling from slits or indentations of the bronchial mucosa in the left main bronchus. A small orifice was located on the medial wall of the left main bronchus. The diverticulum at the left main bronchus was resected with right thoracotomy. Histologically, it was characterized by a lining wall of stratified columnar ciliated epithelium and the presence of smooth muscle and cartilage in the wall (Figure 3).

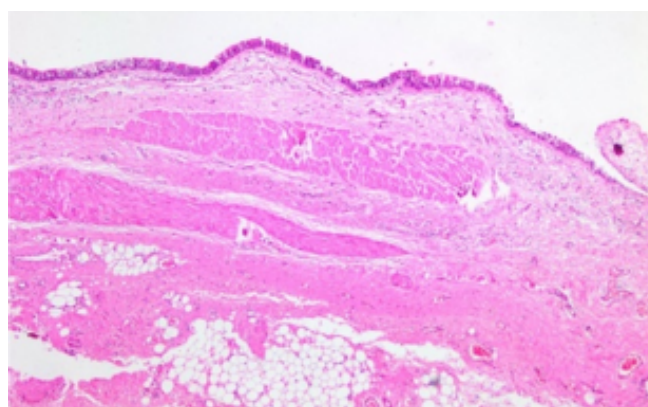


Figure 3. Fibrous tissue and smooth muscle bundles without cartilage tissue under the respiratory epithelium, bronchial diverticulum.

After 15 days, the left paraaortic mediastinal bronchogenic cyst was completely resected with small left thoracotomy. Histologic examination showed a cyst filled with viscid and turbid fluid formed by ciliated columnar epithelial, hyaline cartilage and smooth muscle (Figure 4).

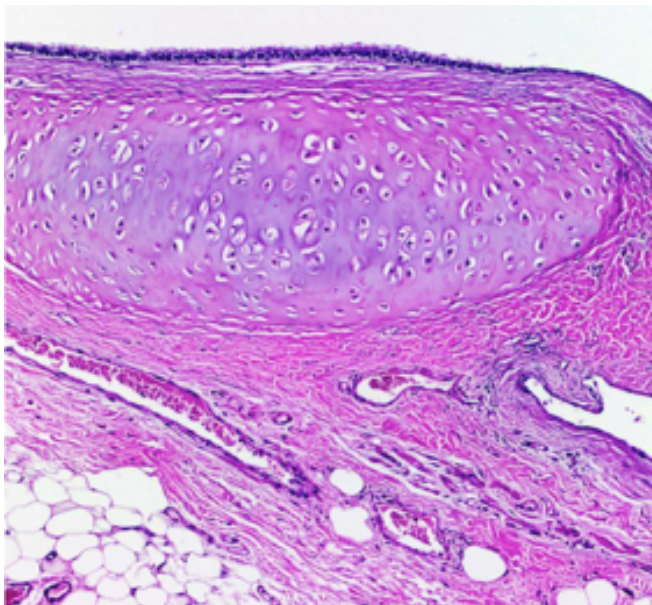


Figure 4. Cartilage tissue under the respiratory epithelium, bronchogenic cyst.

The postoperative course was uneventful and the whistling disappeared. The patient was discharged on the 6th postoperative day. No recurrence or bronchopneumonia has been observed for the last 3 years.

Written informed consent was obtained from the patient for publication of his data.

Discussion

Diverticula of the trachea and bronchus are usually classified into two types, congenital and acquired. Congenital diverticula are thought to correspond to a rudimentary accessory bronchus that is usually located in the posteromedial border of the right main bronchus or the posterolateral border of the lower trachea. Therefore, most reported congenital diverticula have been located in these sites [3]. In our young patient, bronchial diverticulum was in the left main bronchus and associated with recurrent infections of the lower airways, which were more severe in the left lung. We considered the diverticulum to be congenital in our patient as the patient was young and symptomatic for a long time. The acquired type is thought to be associated with some inherent weakness in the tracheal or bronchial walls. Previous studies have demonstrated that acquired bronchial diverticula have a significant association with chronic obstructive pulmonary disease and smoking-related lung disease [4].

Mediastinal air cysts due to bronchogenic diverticulum are extremely rare, and their differential diagnosis

may include tracheocele (also known as paratracheal air cyst or tracheal diverticulum), bronchogenic cyst, and bronchopulmonary foregut duplication cyst [5].

A bronchial diverticulum is usually asymptomatic. If it becomes a large cavitory lesion filled with secretions, it can cause chronic cough, recurrent respiratory tract infections, hemoptysis, dyspnea or stridor [6]. Bronchial diverticula could act as a reservoir for bronchial secretions and theoretically predispose to repeated respiratory infections. In our case, whistling was audible and recorded only on the left side of the sternum. Flexible bronchoscopy demonstrated the airflow through a small orifice. From this observation, it was concluded that this diverticulum caused the whistling.

There is no indication for resection since most diverticula have no symptoms and complications. When infection occurs repeatedly in such a diverticula, however, resection should be done [3]. Because our patient complained of whistling and history of recurrent bronchopneumonia infection due to bronchial diverticulum, the operation was performed.

Bronchogenic mediastinal cysts are congenital lesions located usually in the middle or posterior areas of the mediastinum. The mediastinum or lung locations of bronchogenic cysts are related to the time of separation from the tracheobronchial tree. Both congenital diverticulum and bronchogenic cyst originate from the tracheobronchial tree. Therefore, we believe they are seen together. The bronchogenic cysts are usually asymptomatic and often diagnosed incidentally during routine chest roentgenogram for other reasons. The treatment options depend on the patients' age and symptoms at presentation [2]. In young patients the surgical resection of cysts is the only treatment of choice, however, in asymptomatic adult patients remains controversial owing to the unpredictability complications or degeneration.

In conclusion, we reported a diverticulum originating from the left main bronchus with recurrent bronchopneumonia and whistling since 15 years ago. When a patient displays signs of whistling, we have to consider bronchial lesions, such as bronchial diverticulum. When infection occurs repeatedly in such diverticula, resection should be done. To the best of our knowledge, there has been no case of congenital bronchial diverticula localized in the left main bronchus associated with a paraaortic mediastinal bronchogenic cyst in the medical literature.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support.

Acknowledgments

We would like to thank İlknur Küçükosmanoğlu for helping in histopathological evaluation.

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Case Report

An interesting chest wall tumor: lung cancer metastasis

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ABSTRACT

Many treatment options are available for lung cancer, with the highest mortality among males. Pulmonary malignancies can be addressed by a wide spectrum of treatment approaches. Treatment options can be selected according to tumor localization. Chest wall metastasis, as reported in this study, is a very rare clinical condition in which the chest wall generally requires reconstruction after resection of the tumor.

Keywords: lung cancer, chest wall, metastasis, reconstruction

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Doi: 10.26663/cts.2020.00020

Received 01.04.2020 accepted 17.07.2020

This case was presented as poster in 19th CWIG (Chest Wall International Group) Annual Meeting, June 13-15, 2018, Seoul, Korea.

Introduction

Lung cancer causes relatively high mortality among males. Several approaches to diagnosing and treating the disease have been well established. In most cases, a multi-modal approach is the gold standard treatment. However, complete resection and the presence of nodal involvement, particularly at the N2 station, have been reported as poor prognostic factors for non-small-cell lung cancer with chest wall invasion [1]. In the case of isolated chest wall invasion with tumor complication, the resection and reconstruction of the chest wall become inevitable in appropriate cases.

Here we aimed to present a rare and interesting chest wall metastasis case of lung cancer.

Case Report

A 53-year-old male diagnosed with lung epidermoid cancer was admitted to our emergency room with bleeding from a tumor located on the right chest wall. The patient had been followed up for 3 years for lung cancer and received neoadjuvant chemotherapy. A right superior bi-lobectomy was performed in 2014. Thereafter, the patient continued to receive radiochemotherapy. In 2015, PET/computed tomography (CT) revealed FDG uptake on the right chest wall. Chemotherapy was continued, but the tumor progressed and invaded the chest wall skin (Figure 1), and bleeding suddenly began. The patient's general condition and vital signs upon admission were normal.



Figure 1. Tumor located on the right chest wall and skin metastasis.

Thoracic CT and magnetic resonance imaging (MRI) were performed to evaluate the tumor size and

borders (Figures 2, 3), and the patient was advised to consult with the plastic surgery clinic. Tumor resection and chest wall reconstruction were planned.

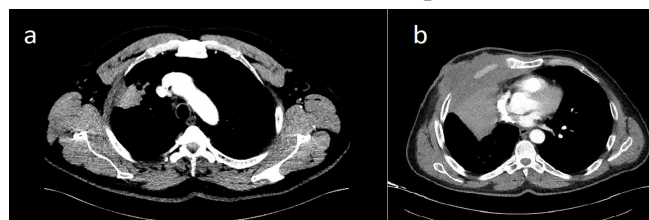


Figure 2 (a) Primary tumor which was located in the right upper lobe before neoadjuvant chemotherapy, (b) thorax computed tomography of the tumor invading the thoracic wall.

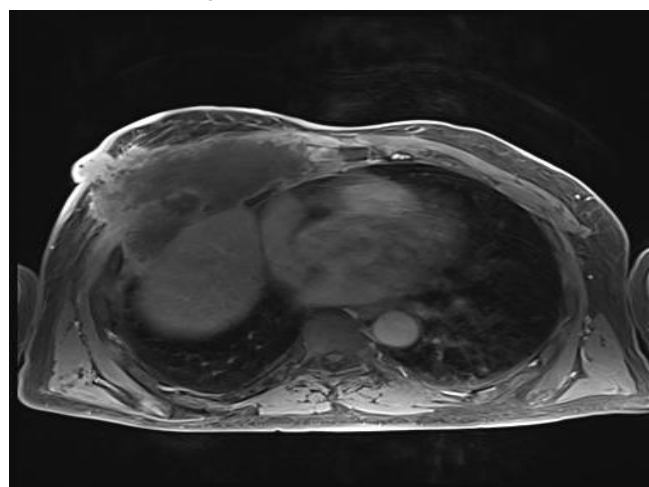


Figure 3. Magnetic resonance imaging of the tumor mass.

During surgery, the tumor, with the anterior portion of the right third, fourth, and fifth ribs (Figure 4), was resected.



Figure 4. Defect of the chest wall after resection of the right third, fourth, and fifth ribs.

Tumor invasion into the lung parenchyma was not found. A latissimus dorsi musculocutaneous flap was used for reconstruction (Figures 5, 6).

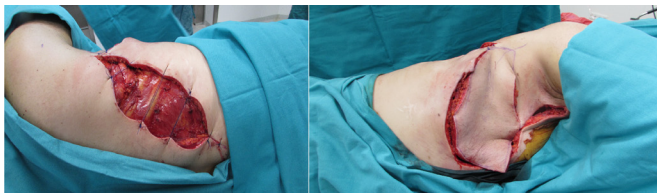


Figure 5. The latissimus dorsi musculocutaneous flap.



Figure 6. Reconstruction of the chest wall.

In the lateral decubitus position, the latissimus dorsi muscle borders are marked and the incisions are planned according to the defect size. The adequate muscle is identified according to the deepness of the defect. Then the pedicle dissection is performed from the inferior angle of the scapula to the inferior. After that, the medial portion and the inferior portion of the flap were dissected, respectively. The flap was tunneled subcutaneously and adapted to the defect area. The patient's pathology indicated lung epidermoid cancer metastasis. Postoperatively, the patient was followed up for 1 month.

Written informed consent was obtained from the patient for publication of his data.

Discussion

Pulmonary malignancies may be addressed by a wide spectrum of treatment approaches. Treatment options can be selected according to tumor localization. Chest wall metastasis is a very rare clinical condition requiring reconstruction after tumor resection. It remains debatable as to whether adjuvant chemotherapy or radiotherapy is mandatory for patients with completely resected chest-wall-invading, non-small-cell carcinoma without nodal involvement [2].

Evaluation of the tumor infiltrating the soft tissues or bones of the chest wall and preparation for complete chest wall resection are necessary to perform radical

surgery. Invasion of the thoracic wall region can be evaluated using CT, bone scan, and MRI [3].

Lung cancer invasion of the chest wall is not a common occurrence, and clinical exploration is necessary for approximately 5% of patients who have undergone resection for lung cancer [4]. When complete resection is attempted, surgeons should use anatomical knowledge to choose the optimum route of access and increase the feasibility of radical resection because of the risk of recurrence. Complete resection is defined as a pathological demonstration of negative tissue margins via frozen sections. In the present case, the resection margin was intraoperatively confirmed using frozen sections for complete resection. The patient's positive cytology findings indicated incomplete resection. Gross residual disease after attempted resection is also classified as palliative resection. If chest wall invasion is preoperatively suspected, chest wall resection including the affected rib should be scheduled.

Resection completeness, nodal status, invasion depth, tumor size, and adjuvant chemotherapy are the prognostic factors for the long-term survival of NSCLC patients with chest wall invasion.

A statistically significant difference in terms of survival rate has been reported among patients who underwent complete resection as compared to the rate among those who received incomplete resection.

The first three ribs are well covered by pectoral muscles and do not need a replacement, primary sutures are adequate. After resection of anterior ribs or more than three ribs to need grafts or free flaps. If you planned to resect ribs, which are located in the backside of the scapula or not enlarged than three ribs, reconstruction is not performed in principle. When necessary, reconstruction of the deficit of the chest wall without synthetic materials should be attempted as soon as possible. In the present case, a latissimus dorsi musculocutaneous flap was created through plastic surgery. Complications were not encountered due to the strength and stability of the mediastinum; neither a graft nor methyl methacrylate was necessary. Successful repair was confirmed by the free flap filling the thorax. Because the lung resection was previously performed, the intercostal spaces

were narrowed on the same side and the muscle flap was sufficient for reconstruction. Besides, the mediastinum was stable and fixed due to radiotherapy, so mediastinal flutter and the flail chest were not expected.

The latissimus dorsi muscle obtains its blood supply from the thoracodorsal artery via the subscapular artery system. Thus, this long pedicle elevates this largest flap for the chest wall defects. The upper edge of this flap is the inferior angle of the scapula; when one is dissecting from superior to inferior, it is important to not dissect the serratus anterior muscle fascia [5]. The serratus muscle fascia should be left intact.

The latissimus dorsi flap allows for the inclusion of the required amount of skin and muscle. The latissimus dorsi musculocutaneous flap is a versatile flap for chest wall reconstruction [6].

In conclusion, pulmonary malignancies may be addressed by a wide spectrum of treatment approaches. Treatment options can be selected according to tumor localization. Chest wall metastasis is a very rare clinical condition requiring reconstruction after tumor resection.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support.

Acknowledgement

We would like to offer special thanks to deceased Assoc. Prof. Dr. Murat Oncel, although no longer with us, for his support and efforts.

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To cite this article: Kavurmacı Ö, Zorlu E, Tekgöl ZT, Arslan M, Özkarakas H. Management of pneumothorax in Covid-19 pandemic: a report of two cases. Curr Thorac Surg 2020;5(2):99-102.

Case Report

Management of pneumothorax in Covid-19 pandemic: a report of two cases

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ABSTRACT

Although the information increases about the lung damage and radiological findings of SARS-CoV-2 disease day by day, the development of pneumothorax has been reported as a very rare finding, and our information is limited with a few case reports. Here we present a 54-year-old male and a 71-year-old female patient, who were diagnosed spontaneous pneumothorax while they were treating for SARS-CoV-2 pneumonia. A tube thoracostomy performed to each patient for the treatment of pneumothorax. While one case treated with tube thoracostomy successfully prolonged air leak, developed in other patient. Spontaneous pneumothorax should be kept in mind as a differential diagnosis when a sudden hypoxia finding developed in respiratory parameters of patients with SARS-CoV-2. Additional measures also should be taken for these patients during treatment with tube thoracostomy.

Keywords: Covid-19, severe acute respiratory syndrome coronavirus 2, pneumothorax, prolonged air leak, tube thoracostomy, pandemic

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Doi: 10.26663/cts.2020.00021

Received 11.06.2019 accepted 20.07.2019

Introduction

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) disease ongoing since started in December 2019 in Wuhan and declared as a pandemic on 12 March by WHO [1-4]. Since the first cases, patients have been reported with pneumonia symptoms like fever, cough, and dyspnea so detection of lung damage has become more important [2-4].

Despite severe lung injury and detailed radiological examinations of lungs, the number of patients with pneumothorax obtained very rare and reported as 2% [2,3]. Our experience with pneumothorax treatment is also limited. Treatment methods for patients with prolonged air leak is an undiscussed topic and concomitant pneumonia may limit the chance of surgical treatment. Air leakage from traditional drainage bottles is another issue because of virus spread. In our study, all of these difficulties were tried to open discussion with two case presentation.

Case 1

A 54-year-old male patient, who was followed up with a diagnosis of acute myeloid leukemia, was obtained cough and fever (38.5-39°C) 6 days after consolidation chemotherapy in the hospital. Dyspnea also added to his complaints, and oxygen saturation regressed to (80%) (without oxygen). In biochemical examinations; white blood cell $0.22 \times 10^3/\mu\text{L}$, hemoglobin 8.8 g/dL, hematocrit 22.3%, platelet $13 \times 10^3/\mu\text{L}$, lymphocyte $0.10 \times 10^3/\mu\text{L}$, INR 1.61, D-dimer 485 ng/mL, CRP: 233.2 mg/dL. In arterial blood gas examination, pH: 7.5, pO₂: 56.3 mm/Hg, pCO₂: 35.2 mm/Hg, HCO₃ 29.3 mmol/L and saturation was: 86.4% with nasal oxygen. Thorax tomography was typical for SARS-CoV-2 pneumonia, with peripheral localized ground glass opacity in the bilateral lungs, more dominant in the lower lobes (Figure 1a).

After blood, urine, and sputum examples were taken for cultures, a combined throat and nose swab were taken for the PCR test. In addition to empirical antibiotic therapy, hydroxychloroquine, oseltamivir, and favipiravir treatment also started for the preliminary diagnosis of SARS-CoV-2. PCR result was (+), additionally, acinetobacter reproduction was detected in the sputum culture. Acinetobacter reproduction was not obtained in control sputum cultures so the result was evaluated as contamination. In the third day of antiviral treatment, the patient was taken to the intensive care unit (ICU) and intubated because of progression in hypoxia findings. Total pneu-

mothorax was detected on the control x-ray, and a 32F tube thoracostomy was performed without any complication (Figure 1b). Control x-ray was compatible with minimal expansion defect (Figure 1c).

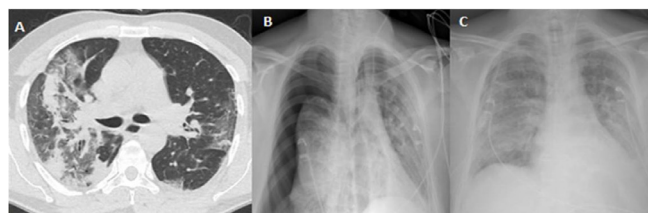


Figure 1. Radiological examinations of case 1, (a) peripheral consolidations and ground-glass opacities in bilateral lungs, more pronounced on the right, (b) pneumothorax in the right hemithorax, (c) expansion defect after tube thoracostomy.

Due to continued air leakage, three different methods were used to prevent virus spread from underwater drainage system to ICU air. Primarily, two interconnected drainage bottles were used for the drainage system. Secondly, 70% concentration of ethyl alcohol was placed in the first bottle, and diluted (10%) sodium hypochlorite (NaOCl) was in the other, finally, an HME (bacterial/viral heat and moisture exchanger) was placed in the air outlet cannula (Figure 2).



Figure 2. The combined use of traditional drainage bottles to prevent virus spread. The first bottle is connected to a second bottle with a hose. One bottle contains 70% ethyl alcohol and the other bottle contains 10% concentration NaOCl. A viral/bacterial filter has also been added to the air cannula of the last bottle.

Air leakage continued without decreasing and surgical resection was not considered due to pneumonic infiltrations and the patient's general septic condition. Despite all antiviral, antibiotic, and supportive treatments, the patient's pneumonic consolidations in chest x-ray did not decrease, additionally, D-dimer

levels increased near 12,450 ng/ml and procalcitonin levels 43 ng/mL. Autologous blood-patch pleurodesis was attempted on day 12 but had no effect. During the follow up period, multiple secondary problems developed such as lower gastrointestinal bleeding, acute renal failure, peripheral arterial insufficiency, and on day 13, (after tube thoracostomy) patient died due to multiorgan failure and sepsis.

Case 2

A 71-year-old female patient who does not have additional disease except essential hypertension was admitted with complaints of fever and anorexia for 3 days. In biochemical examinations; white blood cell $4.24 \times 10^3/\mu\text{L}$, hemoglobin 14.4 g/dL, hematocrit 43.0%, platelet $179 \times 10^3/\mu\text{L}$, lymphocyte $1.8 \times 10^3/\mu\text{L}$, INR 1.19, D-dimer 282 ng/mL, CRP: 53.9 mg/dL. In arterial blood gas examination, pH: 7.5, pO₂: 80.5 mm/Hg, pCO₂: 34.4 mm/Hg, HCO₃ 28.5 mmol/L and saturation was 98.0%. Thorax tomography findings were less severe than case 1, but again typical for SARS-CoV-2 pneumonia. There was peripheral localized ground glass opacity in the bilateral lungs, more dominant in the lower lobes (Figure 3a).

A combined throat and nose swab were taken for the PCR test and the result was (+). Empirical antibiotic therapy, hydroxychloroquine, and enoxaparin treatment started. Favipiravir and tocilizumab were also added to her treatment because of increased CRP and D-dimer values and newly developed dyspnea during the follow-up period (CRP: 168 mg/dL, D-dimer: 679 ng/mL). Despite all the treatments, dyspnea progressed and non-invasive mechanical ventilation support was not enough for solve hypoxia problems so the patient was intubated on day 7. On the third day after intubation, mechanical ventilator pressures were increased and on physical examination, decreased respiratory sounds obtained in the right hemithorax. Right pneumothorax detected on chest x-ray (Figure 3b) and then tube thoracostomy applied (Figure 3c). The air leak stopped early in this case and the thorax drainage was terminated on day 4.

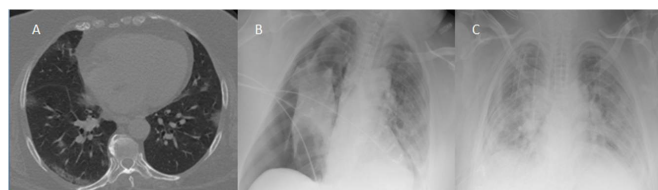


Figure 3. Radiological examinations of case 2, (a) Peripheral consolidations and ground-glass opacities in bilateral lungs, (b) pneumothorax in the right hemithorax, (c) early chest x-ray after tube thoracostomy.

Written informed consent was obtained from the patients for publication of their data.

Discussion

Coronavirus pandemic continues to threaten the world and as of May 31, 2020, SARS-CoV-2 has been reported over 5,9 million cases and 367,166 deaths have been confirmed [5]. Although new and different complaints such as anosmia, facial paralysis are defined today, it is known that most patients have lower respiratory tract complaints such as fever, cough, and dyspnea [2-4]. These respiratory complaints have led doctors to use thorax tomography intensively, and today, findings associated with coronavirus pneumonia at the time of diagnosis and follow period have been well identified [3,4].

Characteristically known features are bilateral multilobar ground-glass opacification (GGO) with peripheral or posterior dominant distribution and mainly in the lower lobes [3,4,6,7]. Depending on the stage of the disease, septal thickening, bronchiectasis, subpleural involvement, and pulmonary artery thrombosis can be added [3,4,6,7]. Pleural/pericardial effusion, lymphadenopathy, parenchymal cavitation, and pneumothorax has been reported rarely seen in the literature [3]. Chen et al reported 99 patients with pneumonia in their study, and they experienced only 1 case with pneumothorax [2]. Similar, Yang et al examined 52 intensive care patients retrospectively and reported pneumothorax in only one patient [8]. Unfortunately, there is no detailed information about treatment models for pneumothorax in these studies. An interesting case reported by Sun et al in a male patient who did not have a lung disease and had no bulla on thorax tomography before [6]. After SARS-CoV-2 pneumonia diagnosis, a new bulla developed during the follow up period and pneumothorax accompanied. However, in this case, the patient did not undergo tube thoracostomy. Similar to this patient, there was no history of lung disease or a bulla-bleb structure in thorax tomography of our cases too.

Tube thoracostomy experience is also limited in this special patient group and traditional drainage bottle safety is an important topic. As it is known, while using traditional drainage bottles, leaked air passes from alveoli to pleural space than pass from water and reach directly to the atmosphere. During this track, the infected air in the alveoli can pass the intensive care air and this can be a way to spread the virus. With this

concern, protective measures were tried to be taken. First of all, the air was passed through the liquid barrier twice by using 2 thorax bottles. At these stages, 70% ethyl alcohol was added to the first bottle and diluted (10%) NaOCl was added to the second bottle. Finally, an HME filter is placed on the air outlet cannula. The minimal resistance of HME to air pass was ignored. During the follow-up of case 1, a negative aspirator was also used for a while to ensure full expansion.

Prolonged air leak is another additional problem in these patients. Aiolfi et al reported successful results with thoracoscopic blep resection in two SARS-CoV-2 and iatrogenic pneumothorax patients for persistent pneumothoraces [9]. In our study, prolonged air leak occurred in only one case and thoracoscopic resection was not considered due to the general septic condition and diffuse lung damage.

Since there was few experience in SARS-CoV-2 in the literature, we could compare our patients with the previous similar coronavirus outbreaks patients for developing another view. In the study reported by Felice about SARS CoV-1 in 2004, the rate of spontaneous pneumothorax was reported as 1.7%. In all patients who applied tube thoracostomy developed prolonged air leakage or recurrence and air leaks took 14 to 31 days (mean of 23.5 days) to resolve [10]. In this respect, prolonged air leak seems predictable because of lung parenchyma inflammation and damage. Severe pneumonic conditions can also hinder the patient's surgical treatment possibility.

In conclusion, our knowledge about the coexistence of SARS-CoV-2 and pneumothorax is limited. We have a little experience in which patients pneumothorax develops, what have to do in a prolonged air leak and which measures have to be taken to prevent virus distribution from the bottle. Additional measures also should be taken for these patients during treatment with tube thoracostomy. We believe that our study will be a benefit case to start a discussion about these important issues.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support.

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All tables and figures must be numbered consecutively as they are referred to in the text. Please refer to tables and figures with capitalization and unabbreviated (e.g., “As shown in Figure 2...”, and not “Fig. 2” or “figure 2”). The tables and

figures themselves should be given at the end of the text only, after the references, not in the running text.

The resolution of images should not be less than 118 pixels/cm when width is set to 16 cm. Images must be scanned at 1200 dpi resolution and submitted in jpeg or tiff format. Graphs and diagrams must be drawn with a line weight between 0.5 and 1 point.

Graphs and diagrams with a line weight of less than 0.5 point or more than 1 point are not accepted. Scanned or photocopied graphs and diagrams are not accepted.

Charts must be prepared in 2 dimensions unless required by the data used. Charts unnecessarily prepared in 3 dimensions are not accepted.

Figures that are charts, diagrams, or drawings must be submitted in a modifiable format, i.e. our graphics personnel should be able to modify them. Therefore, if the program with which the figure is drawn has a “save as” option, it must be saved as *.ai or *.pdf. If the “save as” option does not include these extensions, the figure must be copied and pasted into a blank Microsoft Word document as an editable object. It must not be pasted as an image file (tiff, jpeg, or eps) unless it is a photograph.

Tables and figures, including caption, title, column heads, and footnotes, must not exceed 16x20 cm and should be no smaller than 8 cm in width. For all tables, please use Word’s “Create Table” feature, with no tabbed text or tables created with spaces and drawn lines. Please do not duplicate information that is already presented in the figures.

Tables must be clearly typed, each on a separate sheet, and double-spaced. Tables may be continued on another sheet if necessary, but the dimensions stated above still apply.

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