



Developing a scoring system to select cases requiring chest radiography following catheterization of the central venous

Catheterization of the central venous

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Abstract

Aim: Central venous catheterization (CVC) is a standard intervention with various side effects such as pneumothorax. The principle of routine chest radiography following catheterization has been recently challenged. The present research seeks to develop a scoring system to select patients requiring radiography following central venous catheterization. Material and Method: As many as 210 patients requiring central venous catheterization participated in this cross-sectional research. They were assessed and studied concerning pneumothorax risk factors including a body mass above 30, history of emphysematous disease or neck and chest cage surgery, a history of catheterization, number of punctures, inappropriate position during CVC, treatment with a ventilator. Finally, the pre- and post-catheterization chest radiographs were compared to one another, and the sensitivity and specificity of the scoring system were measured. Results: A frequency of 5.24% was reported for pneumothorax. There was a significant correlation between the number of punctures, patient's position and history of catheterization with the occurrence of pneumothorax ($P < 0.001$). A frequency of 80% was observed for pneumothorax with a score above 4. This frequency was significantly more than what was noted in the group with a score less than 4 ($P < 0.001$; OR: 174.2). The sensitivity and specificity of the scoring system used for the score above 2 were 81.8% and 87.9% respectively. Discussion: According to the results achieved in this research, the possibility of pneumothorax among patients with an overall score less than 2 is insignificant, and the routine radiography of the chest following the catheterization is not necessary. However in cases with a score of more than 4, the possibility of pneumothorax is higher, and it is necessary to conduct radiography with short intervals and even more than once.

Keywords

Central Venous Catheterization; Chest Cage Radiography; Pneumothorax; Scoring System

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Introduction

Central venous catheterization (CVC) has become a common intervention in many therapeutic centers, particularly in ICU [1, 2]. The central venous catheterization usually seeks to study hemodynamic variables, prescribe different liquids, medicines, blood products, and parenteral nutrition in critically ill patients. This intervention has serious side effects including pneumothorax, hemothorax, cardiac tamponade, sepsis and thrombosis [1-4]. These side effects are life-threatening even in the best hospitals and with the best equipment [3, 4].

The prevalence of pneumothorax for experienced doctors in 1.5 to 3% [5]. Considering the uncommon yet significant side effects of catheterization, chest cage radiography is routine and mandatory.

Various researches have been conducted recently to study the importance and usefulness of preparing routine chest radiography [6, 7] highlighting its little value. Moulgard et al. pointed to the fact that in simple routine radiographs of the chest cage usually prepared with a low quality increases the possibility of making mistakes and ignoring small pneumothoraxes. On the other hand, iatrogenic pneumothoraxes have no symptoms at first, and air leakage is so slow in critically ill patients undergoing treatment with positive-pressure ventilator, and this will result in delayed pneumothorax. The researchers of the current paper demand the omission of the law which requires routine preparation of radiographs after catheterization [6]. In a 4-year research which studied 2230 cases of catheterization, Pickor et al. showed that all cases of pneumothorax were marked prior to radiography and 48% of all radiographs were unnecessary [8].

Considering the dispute among the researchers and doctors concerning the routine chest radiograph after central venous catheterization, the present research seeks to develop a scoring system for patients requiring chest radiography following the central venous catheterization among the patients hospitalized in the ICU.

Material and Method

This is a cross-sectional research conducted on 210 patients hospitalized in the surgery and intensive care units of Vali Asr (PBUH) Hospital pf Arak city.

Need for central venous catheterization for any reason, a minimum stay of at least four days in the unit, no existence of chest tube and completion of informed consent certificate were the inclusion criteria defined for this research. Patient's death, intervention by other doctors, patient's desire to leave the research and any reason rendering the preparation of radiography impossible were the exclusion criteria of the research.

Obtaining the informed consent of the patient or his protector, all clinical information of the patient including his age, gender, body mass index, background diseases, and history of previous operations were recorded, and the score of each patient was determined based upon the scoring system recommended by the research. Two chest radiographs were made before and after catheterization for each patient. Except for the marked cases which required immediate tracking and timely treatment, the second radiograph of all patients was conducted 8 hours

after catheterization. All processes of catheterization were carried out by a senior general surgery resident.

The scoring system used in the research is presented in Table 1. Finally, SPSS software and Chi-Square and Mann-Whitney U and logistic regression tests were used to analyze the data. ROC curve was also utilized to calculate the sensitivity and specificity of the test.

Table 1. The scoring system used in the research

Variable	Variable status	Score
BMI	30 <	1
	30 >	0
Number of punctures	3 <	2
	1-3	1
Appropriate position	Yes	1
	No	2
Emphysematous disease history	Yes	1
	No	0
Neck and chest surgery history	Yes	1
	No	0
Catheterization history	Yes	1
	No	0
Under ventilator	Yes	1
	No	0

Results

As many as 136 male (64.8%) and 74 female (35.2%) patients were studied in this research. The average age of the patients was 49.22 ± 95.146 years. The clinical information of the patients is presented in Table 2.

Table 2. The clinical information of the patients studied during catheterization

Variable	Frequency	percentage	
History of Emphysematous	Yes	39	18.6
	No	171	0.4
History of neck or chest surgery	Yes	6	2.9
	No	204	97.1
Hospitalization unit	ICU	52	24.8
	Other units	158	75.23
	Access to central venous	102	48.57
Reason of catheterization	Need for complete parenteral nutrition	26	12.39
	Central venous blood pressure control	75	35.71
	Plasmapheresis	3	1.43
Catheterization site	Subclavian vein	199	94.76
	Jugular vein	5	2.38

The average length of preparing chest radiography after catheterization was 7.313 ± 2.11 hours (range: 1-24). Of all the patients undergoing catheterization for various reasons, 11 cases of pneumothorax (5.24%) and 1 case of hemothorax (0.5%) were observed, and ten patients underwent treatment using chest tube. The diagnosis of all cases suspicious of pneumothorax and hemothorax in the clinical examination was proved by preparing chest radiography.

As hemothorax was observed in only one patient in this

research, it was by no means possible to statistically study the correlation between the occurrence of hemothorax and the risk factors discussed in the current paper.

Of all the patients studied, 103 cases were under ventilator where 5 cases of pneumothorax were observed. No significant correlation was observed between ventilator and occurrence of pneumothorax ($P = 0.807$).

As it is shown in Table 3, there is a significant correlation between the number of punctures, patient's position (appropriate position), and history of catheterization with the occurrence of pneumothorax.

Table 3. Studying the correlation between the factors influencing the scoring system and occurrence of pneumothorax

Variable	Pneumothorax		P
		Total (positive cases of pneumothorax)	
BMI	30 >	188 (9)	0.391
	30 <	22 (2)	
Number of punctures	1-3	194 (2)	< 0.001
	3 <	16 (9)	
Patient's position	Appropriate	197 (3)	< 0.001
	Inappropriate	13 (8)	
History of Emphysematous	Yes	39 (4)	0.119
	No	171 (7)	
History of neck or chest operation	Yes	6 (0)	0.559
	No	204 (11)	
History of catheterization	Yes	5 (2)	< 0.001
	No	205 (9)	
Treatment with ventilator	Yes	103 (5)	0.807
	No	107 (6)	

Using the recommended scoring system (Table 1), an individual score ranging from 1 to 6 was calculated for each patient. Initially, a score of 1 to 4 was designated as low risk for occurrence of pneumothorax, and a score of $4 \leq$ was considered highly risky. The occurrence of pneumothorax among patients with a score of $4 \leq$ was significantly more ($P < 0.001$). According to the present research, the possibility of pneumothorax is 80% if the score exceeds 4.

Logistic regression method was also utilized to analyze the data. In logistic regression according to Enter's method, the following chance of pneumothorax occurrence in number of punctures with OR:4.26 ($CI_{95\%}$: 2.24-8.093 & $P < 0.001$), patient's position with OR: 103.47 ($CI_{95\%}$: 20.963-510.675 & $P < 0.001$) and history of catheterization with OR:14.519 ($CI_{95\%}$: 2.98-15.033 & $P < 0.006$) were reported.

Logistic regression according to Enter method was also conducted for patient's score based upon the above-said categorization. In this research, the chance of pneumothorax occurrence in the group with a high risk of pneumothorax (a score of 4 or more) and OR:174.2 ($CI_{95\%}$: 30.290-1002 & $P < 0.001$) was calculated.

The sensitivity and specificity of the scoring system used in this research were calculated by drawing ROC curve to determine the risk of pneumothorax occurrence. These two variables for a score of 2.5 or more were 81.8% and 87.9%, respectively.

Discussion

Based on the results of the present research, more than three punctures, inappropriate patient's position, and the previous history of catheterization have a significant correlation with the occurrence of pneumothorax. The higher number of punctures, inappropriate patient's position and the previous history of catheterization increase the chance of pneumothorax 4, 103 and 14 times respectively.

On the other hand, drawing a division between the scores obtained from the scoring system and dividing them into low risk (1 to 4) and high risk (4 or more) indicates a higher chance of pneumothorax in the high-risk group.

Utilization of portable method in preparing the radiography of some patients and the low quality of some radiographs were the limitations of this research, and a lot of efforts were made to keep these cases at the minimum level. The small number of hemothorax occurrence rendered the statistical analysis impossible.

According to the results of the present research, if the score obtained through the scoring system is less than 2, the possibility of pneumothorax occurrence will be very little (approximately 0), and the routine radiography of the chest will not be necessary. If the resulting score exceeds 4, the possibility of pneumothorax will be high, and chest radiography will be necessary more than once and with short intervals. In the present research, catheterization by trained and skillful people is described as a safe intervention [6].

In a research by Pickor et al., where 2230 cases of catheterization were studied, the prevalence of pneumothorax was 0.58% which was much less than the occurrence rate in the current research. This probably indicates the importance of the intervening doctor's skill. The present research found 48% of post-catheterization radiographs useless [8].

On the other hand, as all 11 cases of pneumothorax occurrence and 1 case of hemothorax were initially reported based upon suspicious clinical symptoms and later proved by chest radiography, the value of routine chest radiography is still disputed. In Pickor's research, all cases of pneumothorax were initially diagnosed by clinical symptoms. In his research, he has reaffirmed the importance of paying attention to clinical symptoms if it is necessary to prepare radiography [8]. Simultaneous attention to the score and clinical symptoms of the patient is necessary to decide about radiography.

Because a rise in the score of the patient and the effective variables results in the higher risk of pneumothorax, interventions in patients with a score of 4 or more is recommended to be conducted under sonographic or fluoroscopic guide to reduce the chance of pneumothorax occurrence. Interventions by an experienced physician is a useful method to reduce the possibility of influential complications.

Recent studies and guidelines have recommended catheterization under sonographic or fluoroscopic guide in adults as well as children. This intervention has been described as a factor which reduces the possibility of pneumothorax and other complications of catheterization [9-11].

Conclusion

The acceptable sensitivity and specificity of the scoring system used in this research and its simple utilization can help us in making decisions to prepare chest radiography following catheterization. We recommend further researches in various centers to measure the validity of the present system of scoring so that preparation of chest radiography after catheterization becomes purposeful and less time and equipment be wasted.

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