

An Evaluation of Complications in Ultrasound-Guided Central Venous Catheter Insertion in the Emergency Department

Acil Serviste Ultrasonografi Eşliğinde Takılan Santral Venöz Kataterlerin Komplikasyon Açısından Değerlendirilmesi

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SUMMARY

Objectives

In emergency departments, emergency physicians frequently have to perform central venous access. In cases where peripheral venous access is not possible, central venous access is required for dialysis, fulfillment of urgent fluid need, or central venous pressure measurement. This study was carried out to evaluate the emergence of complications in the process of and in the 15 days following the insertion of central venous catheter under ultrasound guidance in the emergency department.

Methods

For this study, patients who presented to the emergency department over a period of eight months with an urgent need for central catheter were examined prospectively. Age, gender, and accompanying diseases of patients as well as the type, time, duration, and indication of the venous access were recorded. Furthermore, the amount of experience of the physician was taken into consideration.

Results

In the emergency department, physicians performed ultrasound-guided central venous catheter insertion for 74 patients (40 men and 34 women). For access, internal jugular vein was used in 65 (87.8%) patients, and femoral vein was used in 9 (12.2%) patients. The reason for access was urgent dialysis need in 55 (74.3%), CVP measurement in 3 (4.1%), fluid support due to severe hypovolemia in 6 (8.1%), and difficulty of peripheral venous access in 10 (13.5%) patients. None of the patients developed complications in the process of or after the insertion. Patients did not have infections related to the catheter in 15 days following the insertion.

Conclusions

Central venous access is frequently required in emergency departments. The risk of complication is little if any in ultrasonography-guided access carried out under appropriate conditions.

Key words: Central venous catheter; emergency department; ultrasound-guided.

ÖZET

Amaç

Acil servislerde acil tıp hekimlerince santral damar yolu işlemi sık uygulanır. Periferik damar yolu açılmadığı hallerde, diyaliz, acil sıvı ihtiyacı veya santral venöz basınç ölçümü gereken durumlarda hastalar için santral damar yolu gerekmektedir. Acil serviste, ultrasonografi (USG) kılavuzluğunda uygulanan acil santral venöz katater girişimi sürecinde ve uygulamayı takip eden 15 gün içerisinde komplikasyon varlığını değerlendirmek amacı ile bu çalışma yapıldı.

Gereç ve Yöntem

Sekiz aylık sürede acil servise başvuran ve acil santral katater gereksinimi olan hastalar ileriye dönük olarak incelendi. Hastaların yaşı, cinsiyeti, eşlik eden hastalıkları ile tercih edilen girişimin yolu, saati, süresi ve endikasyonu kaydedildi. Ayrıca girişimi yapan hekimin çalışma yılı da değerlendirmeye dahil edildi.

Bulgular

Ultrasonografi eşliğinde santral venöz katater takılan 74 (40 erkek, 34 kadın) hastanın 65'inde (%87.8) internal juguler ven, dokuzunda (%12.2) femoral ven girişim için kullanıldı. Uygulama olguların 55'inde (%74.3) acil diyaliz ihtiyacı, üçünde (%4.1) CVP ölçümü, altısında (%8.1) ciddi hipovolemi için sıvı desteği, 10'unda (%13.5) periferik damar yolu güçlüğü nedeniyle yapıldı. Hastaların hiçbirinde işlem esnasında ve sonrasında komplikasyon izlenmedi. Yatırıldıkları bölümde takiplerinde 15 günlük süre içerisinde katater ile ilişkili enfeksiyon da saptanmadı.

Sonuç

Acil servislerde santral damar yolu gereksinimi siktir. Kılavuzların önerisi doğrultusunda USG eşliğinde uygun şartlar altında yapılan girişimlerde komplikasyon riski yok denecek kadar azdır.

Anahtar sözcükler: Santral venöz katater; acil servis; ultrason kılavuzluğu.

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Introduction

The insertion of central venous catheters (CVC) has increased in emergency departments particularly with the spread in usage of ultrasonography (US). While internal jugular vein is commonly preferred for placement under ultrasound guidance, subclavian and femoral vein access has decreased due to higher complication risks. Emergency physicians apply CVC primarily in cases of hemodialysis, difficulty of peripheral venous access, measurement of central venous pressure (CVP), and need for rapid fluid resuscitation.^[1]

Following the insertion of CVC in the emergency department, complications such as infection, pneumothorax, hemothorax, subcutaneous hemorrhage, or puncture of vertebral and cervical arteries, catheter breakage, catheter malposition, thrombus formation, and infection may emerge.^[1-3]

In order to reduce CVC complications, the healthcare personnel placing the CVC is required to work under sterile conditions, be experienced, and use the appropriate technique for each unique patient. The quality of material used is also important.^[4] This study focuses on the complications that may develop in the process of and in the 15 days following the insertion of CVC under ultrasound guidance in our clinic.

Materials and Methods

This study was carried out prospectively in the emergency department of a university between January 2011 and August 2011 after the approval of the local board of ethics was obtained. The study involved patients aged over 18 in urgent need of CVC, who agreed to take part in the study or whose relatives gave consent. Patients with trauma, who were pregnant at the time of admittance, and patients who has two or more septic inflammatory response syndrome criteria^[5] (fever of more than 38°C (100.4°F) or less than 36°C (96.8°F), heart rate of more than 90 beats per minute, respiratory rate of more than 20 breaths per minute or arterial carbon dioxide tension (PaCO₂) of less than 32 mmHg, white blood cell count >12,000/μL or <4,000/μL or >10% immature forms) were excluded. All interventions were performed by emergency physicians under US guidance, who previously received training on US. For the purpose of the study, age, gender, and accompanying diseases of patients as well as the type, time, duration, and indication of the venous access were recorded. Furthermore, the physician's level of experience was taken into consideration. All patients were taken to a unit where vital and cardiac findings were monitored. The patients or their relatives were informed and their consent was received. In supine position, the patients were evaluated for an appropriate vein for US-guided intervention. For this purpose, the anatomic characteristics of the patients as

well as the proximity of vein to the skin, lumen diameters, and the proximity of vein to vital organs were checked. After the location of access was determined, local skin cleaning was performed with 10% povidone-iodine. The probe was covered with sterile glove (Figure 1) and area of access was covered with sterile drape. Once sterility was assured, sedoanalgesia and/or local anesthesia were administered with the agents appropriate for the clinical situation of each patient. 7.5 MHz linear probe, used in US scan (Sonosite, Titan) was covered appropriately. The vascular structures in the relevant area were displayed on the transverse axis (Figure 2). The intervention was performed on the location where the vein is most proximate to the skin, the lumen is largest, and the adjacent artery is most protected. During the intervention, the needle movements were followed on the US screen dynamically. When the blood flow into the injector in the vein became clear, the catheter (double lumen hemodialysis catheter, 12F, 15 cm, Sentia) was placed using the Seldinger method. Blood and fluid flow were checked using heparin-containing fluid (50 U/ml), administered through the catheter. Following the intervention, all patients were checked for subcutaneous emphysema, local hematoma, and bleeding by physical examination, for pneumothorax and hemothorax by US, and for the position of catheters and again pneumothorax and hemothorax by chest radiography. Then, in the intensive care unit or other departments where patients were transferred, they were observed for 15 days to detect any CVC-induced infections or other complications due to catheter placement by emergency physicians. Rash, temper-

Table 1. Patient characteristics

Properties	n	%
Sex		
Male	40	54.1
Female	34	45.9
Past medical history		
Diabetes mellitus	15	20.3
Renal insufficiency	15	20.3
Hypertension	13	17.6
Malignancy	6	8.1
None	23	31.1
Catheter location		
Internal jugular vein	65	87.8
Femoral vein	9	12.2
Indications		
Dialysis	55	74.4
CVP	3	4.1
Hypovolemia	6	8.1
Difficult peripheral venous access	10	13.5



Figure 1. Ultrasound-guided central venous catheter insertion.

ature rise, and swelling on the location where the catheter was inserted were considered local symptoms of infection and systemic inflammatory response syndrome criteria were considered the systemic symptoms. SPSS 20 was used for data analysis.

Results

Of 74 patients that had central venous catheter insertion, 40 (54.1%) were male and 34 (45.9%) were female. The mean age was 63.7 ± 12.42 (range: 32-85). The medical histories of the patients showed that 15 (20.3%) patients had diabetes mellitus, 15 (20.3%) had chronic renal failure, 13 (17.6%) had hypertension, 6 (8.1%) had malignancy, and 2 (2.7%) had chronic liver disease. In 23 (31.1%) patients, there were no

comorbid diseases in past medical history. Internal jugular vein catheterization was preferred in 65 (87.8%) patients, and femoral vein catheterization was preferred in 9 (12.2%) patients. 29 (39.2%) interventions were performed between 8 am and 4 pm, 31 (41.9%) between 4 pm and 12 am, and 14 (18.9%) between 12 am and 8 am. CVC indicated urgent dialysis need in 55 (74.3%), need for CVP measurement in 3 (4.1%), urgent fluid need due to severe hypovolemia in 6 (8.1%), and difficulty of peripheral venous access in 10 (13.5%) patients. The average duration of the intervention was 12.34 ± 6.54 (range: 6-37) minutes in internal jugular vein access, 14.56 ± 6.3 (range: 6-29) minutes in femoral vein access, and 12.61 ± 6.51 (range: 6-37) minutes in total. The intervention was successful in the first attempt in 52 (70.3%) patients, in the second attempt in 18 (24.3%) patients, and in

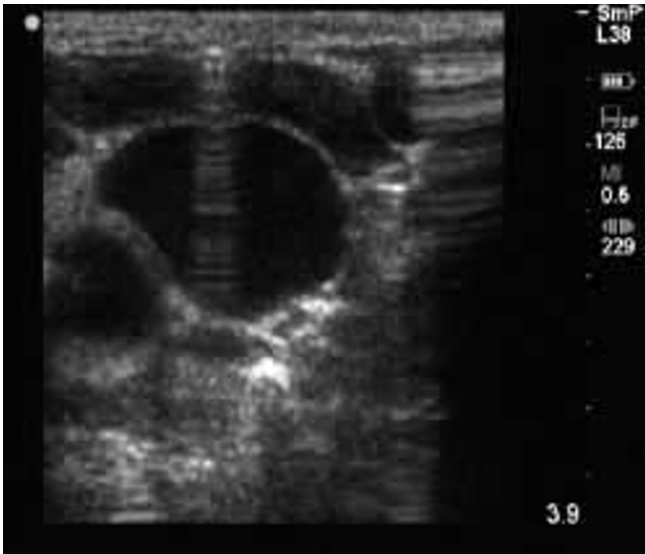


Figure 2. The vascular structures in the relevant area were displayed on the transverse axis.

three or more attempts in 4 (5.5%) patients. 17 (23%) catheters were placed by emergency medical physicians with one year of experience, 25 (33.8%) catheters by physicians with two years of experience, 23 (31.1%) catheters by physicians with three years of experience, 6 (8.1%) catheters by physicians with four years of experience, and 3 (4.1%) catheters by physicians with five years of experience.

In the case of one patient, because blood and fluid flow could not be assured through the catheter inserted in the right internal jugular vein, the intervention was completed successfully from the left. No complication was found in examinations, US, or additional tests performed after the interventions. There was no anomaly in catheter positions, but five patients suffered from temporary dysrhythmia because the catheter was inserted overmuch. In consideration of their clinical indications, 61 (82.4%) patients were transferred to the intensive care unit and 13 (17.6%) patients to other units. Six (8.1%) of these patients died in one week due to causes independent of catheter complications. The 6 patients that died and other patients observed in relevant units for 15 days did not develop local or systemic infections or mechanic complication due to catheter insertion.

Discussion

CVC is a common practice in emergency and intensive care units. The major cases that require CVC are CVP measurement, long-term parenteral treatment, high-concentration fluid and drug administration, recurring blood and blood products administration, hyperalimentation, hemodialysis, and plasmapheresis.

Today, internal jugular veins are frequently preferred for

CVC. Furthermore, external jugular, subclavian, femoral, basilic-cephalic, and rarely portal, inferior vena cava and hepatic veins may be used for this purpose. The Seldinger technique is commonly preferred because it is easy, fast, and reliable. For the patients in our study, the Seldinger method was used, and internal jugular and femoral veins were preferred for insertion.

CVC, which is a vital and life-saving intervention for critical patients, may cause high-cost complications, and the mortality rate of this intervention was reported as 20%.^[6] The literature lists 35 types of complications.^[7] Among the complications that may arise are infection, sepsis, hemorrhage, pneumothorax, air embolism, arterial or nerve laceration, cardiac perforation, arrhythmia, loss of guidewire, catheter malposition, extravasation, infiltration, edema, refractory bleeding, catheter breakage, catheter blockage, and thrombophlebitis.^[7] That is why it is important to control complications by clinical and radiological means after the intervention.

The success of intervention depends on the characteristics of the anatomic location and the experience of the practitioner.^[8,9] The majority of mechanic complications emerge during or right after the intervention. Thrombosis is seen more frequently in cases where the intervention is difficult and the practitioner is inexperienced. The incidence of thrombotic complications ranges between 5 and 50%.^[6] The rate of mortality is high when thrombus breaks up in the catheter and mixes with blood. Additionally, thrombus formation in the catheter is associated with increased infection. Embolism is also a fatal complication of catheter insertion.^[10]

Ventricular dysrhythmia and bundle branch blocks may emerge if the catheter reaches the right atrium during the intervention. Inserting a catheter shorter than 16 cm may prevent these complications.^[11,12] Because of the patients' movements, catheter migration of up to 3 cm is frequent, which shows up in the form of delayed arrhythmia. In our study, 5 patients suffered from temporary dysrhythmia because the catheter was inserted overmuch. The dysrhythmia disappeared when the catheter was brought back to the appropriate location.

Pneumothorax and hemothorax may develop when the practitioner is inexperienced or the patient is in a wrong position. These complications develop more commonly in access through the subclavian vein. That is why, after the intervention, the patient should be observed using physical examination as well as chest radiography and US.

Infection is one of the most frequent complications associated with CVC insertion. Hospital-acquired infection is the most common third infection following ventilator-related

pneumonia and urinary tract infection associated with urinary catheterization.^[13] The Center for Disease Control (CDC) reported that 250,000 catheter-related infections occur annually and that the relevant annual mortality rate is 20%.^[14] Approximately 90% of the bacteremia develops due to CVC.^[15]

With the spread of the use of US in emergency departments, the rate of success in ultrasound-guided interventions has increased, and the risk of complication reduced in the last 5-10 years.^[16,17] The Agency for Healthcare Research and Quality, the Institute of Medicine, and the National Institute for Health and Clinical Excellence recommend that such interventions should be performed under ultrasound guidance.

In internal jugular venous catheterizations, the use of real-time two-dimensional US was reported to yield fewer complications compared to landmark guide techniques.^[17-19] A meta-analysis study, involving 18 researchers and 1646 patients, compared the groups for which US was used and not used, and reported that the use of US reduced complications considerably among both children and adults.^[6] There is no adequate research on subclavian and femoral vein access. In internal jugular vein catheterization, performed in non-emergency cases and without the use of US, carotid artery puncture of 5.9% in average was reported.^[20] In another research, the rate was reported as 3-5%.^[9] The rate increases when catheterization is performed under emergency and by inexperienced physicians.^[21] In cases where there is a delay in diagnosis, hemorrhagic and neurological complications may develop.^[22,23] It is reported in the literature that the rate of carotid artery puncture in US-guided internal jugular vein catheterization ranges between 2 and 9%.^[24] In our study, there was no artery puncture in US-guided catheterization.

It is not recommended to perform catheterization without US on patients with coagulopathy; however, it is also reported that experienced physicians may perform it safely.^[25] In our study, although two patients had coagulopathy (liver failure) (INR of the first patient: 2.1, and INR of the second patient: 1.94), the interventions were completed without any complications. Furthermore, it is reported that the risk of bleeding is highest in patients with thrombocytopenia; however, no bleeding was detected in two patients that were diagnosed with thrombocytopenia in the present study.

In our study, as mentioned above, six patients died in one week after the intervention. The cause of death was respiratory insufficiency in three patients, electrolyte abnormality in two patients, and liver failure in one patient. In the remaining 68 patients, no findings of local infection or SIRS criteria were detected.

In a comparison of our study and literature, we determined fewer complications in our study. Reasons for these results may include careful applications using sterile techniques, accordance with procedural rules, and experienced emergency physicians for US-guided catheterization (minimum 50 procedures per physician).

Conclusion

CVC interventions may cause severe complications when not performed under appropriate conditions. The present study shows that emergency physicians perform CVC interventions under emergency conditions without any complications, provided that the environment is sterile, the appropriate method is selected, and US is used. We believe that the use of US should be more widespread, and emergency physicians should enhance their experience in order to perform these interventions successfully.

Limitations

There were some limitations of our study. There may not be enough patients included in the study to observe complications. Physicians who performed procedures were well experienced. Observing time duration was 15 days.

Conflict of Interest

The authors declare that there is no potential conflicts of interest.

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