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SCIENTIFIC ARTICLE

Comparison of transverse short-axis classic and oblique long-axis ''Syringe-Free'' approaches for internal jugular venous catheterization under ultrasound guidance

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KEYWORDS
Central venous catheter;
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Abstract
Background and objectives: There are different ultrasound probe positions used for internal jugular venous catheter placement. Also, in-plane or out of plane needle approach may be used for catheterization. Transverse short-axis classic approach is the most popular performed approach in literature. ''Syringe-Free'' is a new described technique that is performed with oblique long-axis approach. We aimed to compare performance of these two approaches.
Methods: This study was conducted as a prospective and randomized study. 80 patients were included the study and allocated into two groups that were named Group C (transverse short-axis classic approach) and Group SF (oblique long-axis syringe-free approach) by a computer-generated randomization. The primary outcome was mean time that guidewire is seen in the Internal jugular vein (performing time). The secondary outcomes were to compare number of needle pass, number of skin puncture and complications between two groups.
Results: Demographic and hemodynamic data were not significantly different. The mean performing time was 54.9 ± 19.1 s in Group C and 43.9 ± 15.8 s in Group SF. Significant differences were found between the groups ($p = 0.006$). Mean number of needle pass was 3.2 (± 2.1) in Group C and 2.1 (± 1.6) in Group SF. There were statistically significant differences between two groups ($p = 0.002$). The number of skin puncture was 1.6 (± 0.8) and 1.2 (± 0.5) in Group C and SF, respectively ($p = 0.027$).
Conclusion: ''Syringe-Free'' technique has lower performing time, number of needle pass and skin puncture. Also, it allows to follow progress of guide-wire under continuous ultrasound visualization and the procedure does not need assistance during catheter insertion. Namely, ''Syringe-Free'' is effective, safe and fast technique that may be used to place internal jugular venous catheter.

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PALAVRAS-CHAVE
Cateter venoso central;
Eixo curto transversal;
Eixo longo oblíquo;
Veia jugular interna

Comparação das abordagens clássica transversal no eixo curto e longitudinal oblíqua no eixo longo sem seringa para cateterização de veia jugular interna guiada por ultrassom

Resumo
Justificativa e objetivos: Há diferentes posições do probe do ultrasom que são utilizadas para a colocação de cateter em veia jugular interna. Além disso, a aproximação da agulha no plano ou fora do plano pode ser usada para o cateterismo. A abordagem transversal clássica no eixo curto é a abordagem mais popular na literatura. Sem seringa é uma nova técnica descrita, realizada com a abordagem oblíqua no eixo longo. Nosso objetivo foi comparar o desempenho dessas duas abordagens.
Métodos: Este foi um estudo prospectivo e randômico. No total, 80 pacientes foram incluídos no estudo e divididos em dois grupos denominados Grupo C (abordagem transversal clássica no eixo curto) e Grupo SF (abordagem Sem seringa oblíqua no eixo longo) por meio de randomização gerada por computador. O desfecho primário foi o tempo médio para a visibilização do fio-guia na veia jugular interna (tempo de execução). Os desfechos secundários foram o número de passagens da agulha, o número de punções da pele e as complicações entre os dois grupos.
Resultados: Os dados demográficos e hemodinâmicos não foram significativamente diferentes. O tempo médio de execução foi de 54,9 ± 19,1 segundos no Grupo C e 43,9 ± 15,8 segundos no Grupo SF. Diferenças significativas foram observadas entre os grupos ($p = 0,006$). O número médio de passagens da agulha foi de 3,2 (± 2,1) no Grupo C e 2,1 (± 1,6) no Grupo SF. Houve diferença estatisticamente significativa entre os dois grupos ($p = 0,002$). O número de punções da pele foi de 1,6 (± 0,8) no Grupo C e 1,2 (± 0,5) C no Grupo SF ($p = 0,027$).
Conclusões: A técnica sem seringa apresentou tempo de execução, número de passagens da agulha e número de punções da pele menores. Além disso, essa técnica permite acompanhar o progresso do fio-guia com visibilização ecográfica contínua, e o procedimento não precisa de auxilio durante a inserção do cateter. Ou seja, sem seringa é uma técnica eficaz, segura e rápida que pode ser usada para a colocação de cateter em veia jugular interna.

Introduction

Internal Jugular Central Venous Catheter (IJCVC) insertion is a common procedure in intensive care units and operating rooms. Vascular access may be vital in some situations such as hypotension and unable to be obtained peripheral venous access. IJCVCs may be placed using traditional anatomical landmark technique. Unfortunately, landmark-guided IJCVC placement may be associated with significant complications such as hematoma, pneumothorax and arterial puncture. Ultrasound (US) guidance for Central Venous Catheter (CVC) insertion reduces complication and procedure times and improves success rates according to studies in literature.[1,2] Also, American Society of Anesthesiologists have published a guideline and recommended real-time US guidance be used for IJCVC placement.[3]

Although US usage is associated with increased success rate and fewer attemps,[4,5] carotid artery puncture can be seen during IJCVC placement under US guidance in some studies.[6,7]

There are different usg probe position to view the internal jugular vein and the other anatomical structure for IJCVC insertion. These approaches are transverse (short axis), longitudinal (long axis) and oblique. Also, IJCVC can be placed using both in-plane needle approach and out of plane needle approach under US guidance. Needle tip control can be difficult under transverse out of plane approach.[8,9] Oblique in-plane approach allows visualization of both needle on the US screen as a line with needle tip and the anatomical structures including internal jugular vein and carotid artery.[10]

In all these approaches, blood aspiration is done via a syringe to confirm the location of the vessel (Classic technique). The syringe-free technique has been described recently. The guidewire is placed into the puncture needle and insertion is performed without blood aspiration using oblique probe position and in-plane needle approach.[11]

In this current study, we hypothesize that the syringe-free technique will allow improved performing time and decreased number of needle pass and skin puncture during Internal Jugular Vein (IJV) catheterization under US guidance. Thus, risk of complication will decrease because of less needle manipulation. We aimed to compare effectiveness of transverse out of plane (short axis) approach by using classic technique with oblique in-plane (long axis) approach by using syringe-free technique in terms of performing time and success of catheter placement and complications. This is the first prospective-randomized study compared the transverse short-axis classic approach and oblique long-axis syringe-free approach.

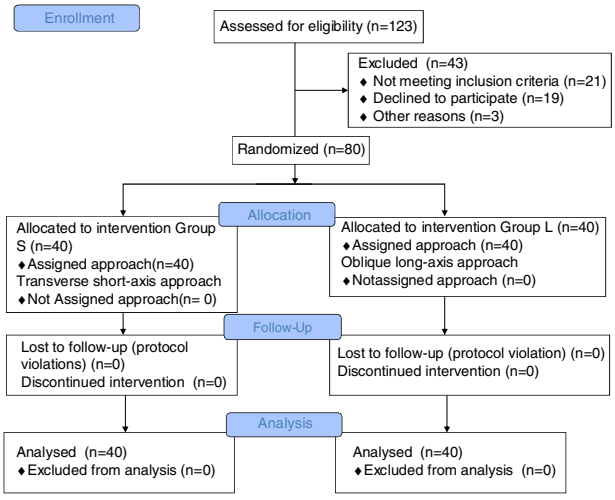

Figure 1 Consolidated Standards of Reporting Trials (CONSORT) flow diagram of patient distribution.

Material and methods

This prospective and randomized study was begun after receiving the approval of the Ataturk University Local Ethics Committee and informed consent of the patients. 80 patients (ASA I-III, 18–65 years old) who operated in Operating Rooms (OR) because of any reason and needed to place catheter were included in the study. The exclusion criteria's were age > 65 and <18, skin infection and previous surgery at the catheterization site, INR > 2, platelet count <50,000, patient who did not accept to participate the study. The patients were divided into two groups by a computer-generated randomization. The group that was placed the IJCV catheter using transverse short-axis classic approach was named Group C ($n = 40$), and the group placed IJCV catheter using oblique long-axis syringe-free approach was named Group SF ($n = 40$). The study flow diagram is shown in Fig. 1.

Right internal jugular vein was chosen for venous catheterization. The right IJV follows a straight (no angulations) course into the Superior Vena Cava (SVC) via the right Innominate Vein (IV), and generally its diameter is larger than the left IJV.[12] Another reason the right side was chosen over the left for cannulation is that the right lung apex is lower than the left lung apex, thus we can decrease the risk of pneumothorax because of inadvertent pleural puncture.[13]

All IJCV catheter placement were performed by same anesthetist who is experienced on ultrasound guided procedures and the procedures were performed by single operator (anesthetist). High frequency linear US probe (EsoateMyLab™ 30 Gold linear probe, 10–18 MHz, Genova, Italy) was used in both two groups.

Patients were monitored standardly with ECG, non-invasive blood pressure and pulse oximeter and placed on supine position. All procedures took place in the ORs under general anesthesia. After entubation, the patient's head was turned toward the controlateral site of catheterization and patients placed in 15 trendelenburg position. We examined IJV on right site before catheter placement in all procedures. After disinfection of catheter placement site using

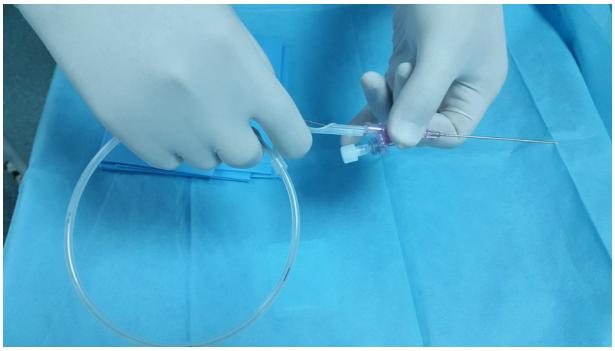

Figure 2 Guidewire adapted to needle.

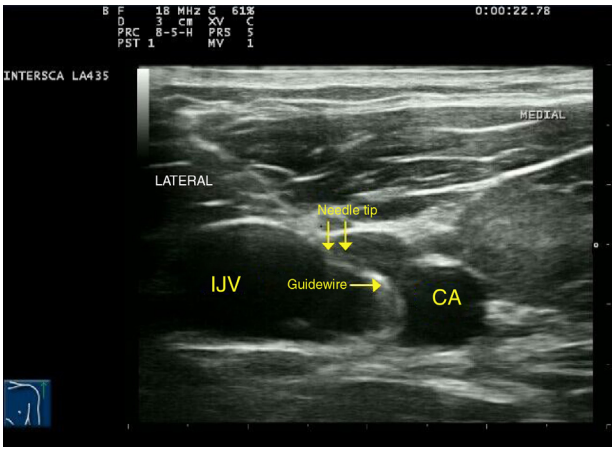

Figure 3 Ultrasound images of needle and guidewire (IJV, internal jugular vein; CA, carotid artery; ↓↓, needle tip; →, guidewire).

povidone iodine, US probe was dressed with a sterile cover. The venous catheter (Certofix® Duo/Trio, BBraun, Germany) was placed using seldinger technique in all cases. In Group C, the ultrasound probe was placed on transverse position over the neck. After IJV and carotid artery identification, the needle connected with a syringe was inserted using out of plane technique. When the needle was seen in IJV as a ''dot'' and aspirated blood, the guidewire was introduced into the IJV and needle was removed. After wire insertion into IJV, we confirmed that the wire was in IJV and was seen as a ''dot'' in transverse probe position. In Group SF, the US probe was placed on transverse position and the IJV and carotid artery identified at first. Then the probe was rotated oblique position and tried to keep the vein and artery image on the US screen. The guide wire was placed into the puncture needle before skin insertion of the needle (Fig. 2). The needle (guidewire adapted) was inserted using in-plane technique and was advanced to the IJV from lateral to medial line of the neck. When the vessel lumen was penetrated by the needle, the guidewire which adapted to the needle was introduced into the IJV under direct continuous US visualization (Fig. 3). The wire position was tried to view as a ''dot'' as Group C and confirmed in IJV. After catheterization, a chest X-Ray was conducted to check for complications and tip of the catheter in all cases.

The catheterization success was defined as successful guidewire insertion and detection by US in IJV. If the

Table 1 Demographic and hemodynamic data.

	Group C $n=40$	Group SF $n=40$	p-value
Age (years)	52.1 ± 12	47.9 ± 13	0.13[a]
Weight (kg)	73.5 ± 15.6	76.6 ± 14.7	0.36[a]
Height (cm)	166.3 ± 7.4	168.4 ± 8.7	0.24[a]
Sex (M/F)	20/20	24/16	0.37[b]
Systolic blood pressure[c] (mmHg)	127.4 ± 28.9	130.7 ± 31.4	0.63[a]
Diastolic blood pressure[c] (mmHg)	74.2 ± 18	71.6 ± 17.6	0.51[a]
Central venous pressure[d] (mmHg)	7.9 ± 3.6	8.2 ± 3.5	0.73[a]

Group C, transverse short-axis classic approach group; Group SF, oblique long-axis syringe-free approach group. Values are expressed in mean $\pm$ SD.
[a] $p > 0.05$, Student-t test.
[b] $p > 0.05$, Chi-Square test.
[c] Pre-procedural values.
[d] First value after catheter placement.

Table 2 Procedure-related data.

	Group C $n=40$	Group SF $n=40$	p-value
Performing time[d] (second)	54.9 ± 19.1 (min = 32; max = 126)	43.9 ± 15.8 (min = 25; max = 111)	0.006[a]
Number of needle pass[d]	3.2 ± 2.1 (min = 1; max = 9)	2.2 ± 1.6 (min = 1; max = 7)	0.027[b]
Number of skin puncture[d]	1.6 ± 0.8 (min = 1; max = 4)	1.2 ± 0.5 (min = 1; max = 3)	0.002[b]
Number of failed attempt	5	3	0.456[c]

Group C, transverse short-axis classic approach group; Group SF, oblique long-axis syringe-free approach group; min, minimum value; max, maximum value.
[a] $p > 0.05$, Student-t test.
[b] $p > 0.05$, Mann–Whitney U test.
[c] $p > 0.05$, Chi-Square test.
[d] Values are expressed in mean $\pm$ SD.

guidewire was not inserted in 3 min in the assigned approach or was inserted in another approach, we defined it as an unsuccessful catheterization. The number of attempt (skin puncture) and redirection of the needle after an attempt (needle pass) until successful wire insertion was recorded in both two groups. Performing time was defined as the time interval between skin puncture of needle and visualization of guidewire in IJV in both two groups. We recorded the performing time as second. The possible complications such as arterial puncture, neck hematoma, pneumothorax, hemothorax and nerve injury were recorded, If any of these complications occurred. Also, patient characteristics as age (year), sex, height (cm), weight (kg) and hemodynamic data (systolic and diastolic blood pressure, first central venous pressure measure after catheter placement) were recorded. The number of skin puncture and needle pass were also recorded in both two groups.

Statistical analysis

We aimed to detect a difference of 15% in performing time between groups and we found that the Standard Deviation (SD) was around 23 s based on the our preliminary study. According to Russ Lenth's Piface Java module, we determined that the number of patients required in each group was 40, based on a power of 82% and alpha error of 0.05.

The statistical analysis was performed by using The Statistical Package for Social Sciences (SPSS Inc, Chicago, IL) 20.0 program. Kolmogorov–Smirnov test was used to evaluate distribution of variables. In the descriptive data analysis, numerical data were presented as mean and standard deviation, and the categorical data were represented as numbers and percentages. Categorical variables were analyzed using the Chi-Square Test. The normally distributed data comprising continuous variables were analyzed using Student's t-test and abnormally distributed data were analyzed using Mann–Whitney U test. $p < 0.05$ was considered statistically significant.

Results

80 eligible patients were randomized and analyzed as shown Consolidated Standards of Reporting Trials (CONSORT) flow diagram (Fig. 1). The patient's' demographic characteristics and hemodynamic data are shown in Table 1. Mean systolic and diastolic blood pressure were in order

of 127.4 (± 28.9) mmHg and 74.2 (± 18) mmHg in Group C. In Group SF, systolic and diastolic blood pressure mean values were 130.7 (± 31.4) mmHg and 71.6 (± 17.6) mmHg, respectively. Mean value of first central venous pressure measure after catheter placement was 7.9 (± 3.6) mmHg and 8.2 ± 3.5 mmHg in Group C and Group SF, respectively. There was no statistically significant difference between two groups related to demographic data ($p > 0.05$).

Procedure-related data are shown in Table 2. The mean time that guidewire is seen in the IJV (performing time) was 54.9 ± 19.1 s and 43.9 ± 15.8 s in Group C and Group SF, respectively. There was statistically significant difference between two groups ($p = 0.006$). The mean number of needle pass was 3.2 (± 2.1) and 2.1 (± 1.6) in Group C and SF, respectively. The number of skin puncture was in order of 1.6 (± 0.8) and 1.2 (± 0.5) in Group C and SF and significant differences were found between the groups (needle pass; $p = 0.002$, skin puncture; $p = 0.027$).

There were no central venous catheter related mechanical complication neither during procedure period (such as arterial puncture, hematoma and pneumothorax) nor during post-procedure period (such as catheter misplacement, catheter fracture) in both two groups.

Discussion

Oblique long-axis syringe-free approach group had shorter performing time, less number of needle pass and skin puncture when compared with transverse short-axis classic approach group. Transverse short-axis and oblique long-axis approaches with classic technique are well-known approaches that used in many study in the literature.[4,14–16] However, syringe- free technique is a new and innovative technique for IJV canulation under US guidance with oblique probe position. There are no randomized-controlled studies on this subject in literature according to our knowledge.

Systolic and diastolic blood pressure and central venous pressure mean values were similar between the groups. A patient's perioperative intravascular volume can change according to many reasons such as comorbidities, fasting, bowel preparation.[17] No doubt that the patient's intravasculer volume should be similar to insert IJV catheter under the same conditions in both two groups. Central venous pressure is an important predictor of intravasculer volume despite different results in the literature.[18] Because of this reason we recorded the pre-procedural blood pressure values and central venous pressure soon after catheter placement. The result was not statistically different between two groups.

According to our results, performing time, number of needle pass and skin puncture was found less in Group SF than Group C and there was statistically significant difference between two groups. We consider that these results showed us benefit and positive effect of syringe-free technique on performing time, number of needle pass a skin puncture. Because, classic technique for central venous catheter insertion is done by blood aspiration. We do not need to blood aspiration when the oblique long-axis syringe-free approach is used. The entire needle and needle tip can be seen continuously. When the needle tip penetrates the IJV, the guide-wire can be inserted under direct continuous US visualization. Syringe-free technique allows us to observe all procedure (entire needle, needle tip position, progression of guide-wire). The US probe has to be left if the classic technique is used. Because, the syringe should be disconnected to insert the wire into the IJV through the needle. The needle tip may be out of IJV or be advanced to other anatomical structures such as carotid artery, lung, etc., although the needle tip is initially identified in the IJV. And interruption of USG imaging may cause complication, prolongation of performing time and may increase the number of needle pass and skin puncture. Also, there were no complications such as arterial puncture, neck hematoma, pneumothorax, hemothorax in both two groups. This can be understandable by the fact that the experience of the operator reduces the risk of complications as with all medical practices.[19] The anesthetist who was performed all IJV catheterization was experienced and skilled on US-guided procedures.

There are some limitations of our current study. The patients hemodynamic values were similar and in normal range. Because, patients were well-prepared preoperatively and intravasculer volumes of patients were replaced before surgical procedure. The results may be different under emergent circumstances such as traffic accident, stabbing and gunshot injury. Central venous catheterization is difficult for patient who has hypovolemia. The oblique long-axis syringe-free approach may not be appropriate choice because of collapsed IJV diameter. Puncture of posterior wall of IJV was not recorded as a complication. Because detection of posterior wall puncture is no reliable in classic technique. In this study, the USG imaging interrupted during the guide-wire insertion in classic group and we could not be sure that needle did not penetrate posterior wall of IJV inadvertently. Infectious complications were also not recorded. Because, it was not our primary outcome. We only recorded the mechanical complications. The other limitation is that all procedures were performed by an experienced anesthetist. The results may be change in case of procedure performed by less experienced anesthetist or operator. Also, we included only adults in our study. The results may be interesting for pediatric patients. Especially, newborns who have low weight and need central venous catheter are under risk of prolonged procedures and increased number of attempt. It can be more difficult to place internal jugular venous catheter because of small lumen of IJV in newborns.[20] If the internal jugular vein is punctured unsuccessfully, the vein may be seen smaller than before on US screen.[21] The syringe-free technique may be useful at this point and a study can be designed.

Conclusion

US-guided different approach may be used for IJV catheterization. Main purpose of using different approaches is to improve the safety and decrease the time consumption or to have another choice in case of unsuccessful attempt of any approach. The Syringe-Free technique has some advantages that it allows to observe entire catheter insertion process in control and follow progression of the guide-wire under ultrasound visualization. According to our results, It seems that oblique long-axis ''Syringe-Free'' approach is a

new, fast, safe, easy to apply, and reliable technique for IJV catheterization and it can be an alternative approach for all operators.

Conflicts of interest

The authors declare no conflicts of interest.

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