



ORIGINAL INVESTIGATION

Risk factors for failure of subclavian vein catheterization: a retrospective observational study

Ren-Xiong Chen, Hong-Zhi Wang *, Yong Yang, Xiao-Jie Chen

Peking University Cancer Hospital & Institute, ICU Department, Key Laboratory of Carcinogenesis and Translational Research, Beijing, China

Received 7 March 2020; accepted 21 February 2021
Available online 20 March 2021

KEYWORDS

Subclavian vein catheterization;
Central venous access;
Central venous catheter;
Catheter-related complications

Abstract

Background and objectives: The aim of this study was to analyze risk factors for failure of subclavian vein catheterization.

Methods: A retrospective analysis of 1562 patients who underwent subclavian vein puncture performed by the same experienced operator at Peking University Cancer Hospital from January 1, 2016 to January 1, 2019 was conducted. The success or failure of subclavian vein catheterization was registered in all cases. Various patient characteristics, including age, gender, body mass index (BMI), preoperative hemoglobin, preoperative hematocrit, preoperative mean corpuscular hemoglobin concentration (MCHC), preoperative albumin, preoperative serum creatinine, puncture needles from different manufacturers and previous history of subclavian vein catheterization were assessed via univariate and multivariate analyses.

Results: For the included patients, landmark-guided subclavian vein puncture was successful in 1476 cases and unsuccessful in 86 cases (success rate of 94.5%). Successful subclavian vein catheterization was achieved via right and left subclavian vein puncture in 1392 and 84 cases, respectively. In univariate analyses, age and preoperative hemoglobin were associated with failure of subclavian vein catheterization. In a multivariate analysis, aged more than 60 years was a risk factor while the central venous access with Certofix® was associated with an increased rate of success (*p*-values of 0.001 and 0.015, respectively).

Conclusions: This study has demonstrated that patient aged more than 60 years was a risk factor for failure of subclavian vein catheterization while the central venous access with Certofix® was associated with an increased rate of success.

© 2021 Sociedade Brasileira de Anestesiologia. Published by Elsevier Editora Ltda. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

* Corresponding author.

E-mail: wanghz58@sina.com (H. Wang).

Introduction

Central venous catheterization is one of the most helpful methods for rapid volume expansion, hemodynamic monitoring, and the administration of parenteral nutrition and chemotherapy. This procedure has been widely used in clinical practice and has been well received by most patients. Locations for central venous catheterization include the subclavian vein, the internal jugular vein, and the femoral vein. Among them, subclavian vein catheterization has the characteristics of adequate blood flow and a low incidence of catheter-related infections.¹⁻³

Nowadays, the number of subclavian and axillary vein punctures performed with ultrasound guidance has markedly increased. However, landmark-guided subclavian vein catheterization using an infraclavicular approach is still one commonly chosen technique in China. The insertion of a catheter by a doctor who had performed 50 or more catheterizations is less likely to result in a mechanical complication than insertion by a doctor who had performed fewer than 50 catheterizations.⁴ Hence, we defined a doctor who had performed 50 or more catheterizations as an experienced operator. Few studies have addressed risk factors for failure of subclavian vein catheterization. Prior reports regarding this topic have involved subclavian vein catheterization performed by multiple operators with different skill levels; these characteristics might influence the research results. In this study, we evaluated 1562 patients who underwent subclavian vein catheterization performed by the same experienced operator to investigate risk factors for failure of subclavian vein catheterization.

Methods

A total of 1562 patients who underwent subclavian vein catheterization at Peking University Cancer Hospital from January 1, 2016 to January 1, 2019 were included. Exclusion criteria: patients with superior vena cava obstruction syndrome. The age, gender, body mass index (BMI), preoperative hemoglobin, preoperative hematocrit, preoperative mean corpuscular hemoglobin concentration (MCHC), preoperative albumin, preoperative serum creatinine, puncture needles from different manufacturers, and previous history of subclavian vein catheterization of the patients were collected.

All catheterization procedures were performed by the same experienced operator in our hospital's Vascular Access Center. The operator had experienced hundreds of subclavian vein puncture and usually preferred the right subclavian vein puncture. The location selected for subclavian vein puncture was approximately 1 cm to 2 cm below the midpoint of the clavicle.⁴ Lidocaine was used for local anesthesia, and the Seldinger technique was used for subclavian vein puncture, with a central venous catheter (Certofix®, BBraun, Melsungen, Germany; or Arrow, USA) inserted at the puncture site. Previous research showed that the use of no more than three needle passes reduced the risk of complications for right infraclavicular subclavian vein catheterization.⁴ Therefore, subclavian vein puncture was defined as a failure after three unsuccessful attempts. We

Table 1 Patient characteristics.

Items (mean ± SD or number)	Result
Age, years	55.5 ± 12.5
Male/female	811/751
Height, m	1.65 ± 0.08
Body weight, kg	66.1 ± 12.3
BMI, kg.m ⁻²	24.2 ± 3.7
Hemoglobin, g.L ⁻¹	130.3 ± 20.2
Hematocrit	39.0 ± 5.3
MCHC, g.L ⁻¹	333.0 ± 14.1
RDW	14.0 ± 2.3
Albumin, g.L ^{-1a}	43.3 ± 4.6
Creatinine, μmol.L ^{-1b}	66.1 ± 15.7
Prior subclavian vein puncture, yes/no	114/1448

Hemoglobin and hematocrit levels were obtained within one month prior to vein puncture. The other values were obtained within one week prior to vein puncture.

BMI, body mass index; MCHC, mean corpuscular hemoglobin concentration; RDW, red cell distribution width.

^a Data were available for 1551 patients.

^b Data were available for 1555 patients.

changed the angle between the puncture needle and the clavicle but did not change the site between those attempts.

In cases involving failure of subclavian vein puncture, we performed ultrasound-guided internal jugular vein puncture, ultrasound-guided axillary vein puncture, or contralateral subclavian vein puncture. The study was approved by the Medical Ethical Committee of Peking University Cancer Hospital. All the participants gave written informed consent before the procedure itself.

Values are presented as the means ± SD or as numbers of patients, expressed as a percentage. To compare patients, average values were analyzed using *t*-tests or the Wilcoxon rank sum test, and proportions were assessed using chi-squared tests. Forward LR of logistic regression was utilized during multivariate analysis. Statistical analyses were performed using SPSS version 24.0. *P*-values less than 0.05 (two-tailed) were regarded as significant.

Results

These patients included 473 cases of colorectal cancer, 265 cases of gastric cancer, 116 cases of ovarian cancer, 89 cases of liver cancer, 77 cases of breast cancer, 53 cases of renal cancer, 50 cases of lymphoma, 40 cases of lung cancer, 16 cases of esophageal cancer, 15 cases of pancreatic cancer, and 368 cases of other tumors. Their ages ranged from 16 to 89 years.

Major baseline characteristics of the included patients are shown in Table 1. In the 1562 included patients, subclavian vein puncture was successful in 1476 cases and unsuccessful in 86 cases. The success rate of subclavian vein puncture was 94.5%. Successful subclavian vein catheterization was achieved via right and left subclavian vein puncture in 1392 and 84 cases, respectively. In 86 cases involving failing subclavian vein puncture, ipsilateral ultrasound-guided internal jugular vein puncture, ipsilateral ultrasound-guided axillary vein puncture, and contralateral subclavian vein

Table 2 The univariate analysis of risk factors for failure of subclavian vein catheterization.

Factors (mean \pm SD or number)	Success (1476)	Failure (86)	<i>p</i> ^a
Age	55.2 \pm 12.5	60.8 \pm 11.6	0.001
Male/female	768/708	43/43	0.714
BMI	24.2 \pm 3.7	23.6 \pm 3.6	0.166
Hemoglobin	130.5 \pm 20.3	126.9 \pm 18.4	0.046
Hematocrit	39.1 \pm 5.3	38.3 \pm 4.9	0.080
MCHC	333.1 \pm 14.1	330.9 \pm 12.7	0.095
RDW	14.0 \pm 2.3	14.0 \pm 2.0	0.654
Albumin	43.3 \pm 4.6	42.7 \pm 4.7 ^b	0.206
Creatinine	66.1 \pm 15.7 ^c	67.0 \pm 16.4 ^d	0.554
Puncture needles from different manufacturers (Certofix/Arrow)	1016/460	51/35	0.065
Prior subclavian-vein puncture, yes/no	106/1370	8/78	0.462

BMI, body mass index; MCHC, mean corpuscular hemoglobin concentration; RDW, red cell distribution width.

^a We used Wilcoxon rank-sum test in the analyses of age, BMI, hemoglobin, hematocrit, MCHC, RDW and albumin; t test in the analysis of creatinine; chi-squared tests in the analyses of sex, types of puncture needle, prior history of subclavian-vein puncture.

^b Data were available for 85 patients.

^c Data were available for 1470 patients.

^d Data were available for 85 patients.

puncture were performed for 49, 34, and 3 patients, respectively.

Chest X-rays were obtained within 48 hours after the subclavian vein catheterization procedure for 1542 patients, whereas no such X-rays were acquired for the remaining 20 patients. There were seven patients with arterial puncture, one with nerve injury, four with postoperative ectopic catheterization of the internal jugular vein, one with postoperative pneumothorax that did not need thoracic drainage, one with pinch-off syndrome, and one with postoperative catheter-related bloodstream infection.

In the univariate analysis, age and preoperative hemoglobin were associated with failure of the subclavian vein puncture (the univariate analysis of the included patients is listed in Table 2). Age, gender, preoperative body mass index (BMI), hemoglobin level, hematocrit, mean corpuscular hemoglobin concentration (MCHC), red cell distribution width (RDW), albumin level, serum creatinine level, puncture needles from different manufacturers, and history of previous subclavian vein puncture were included in multivariate analysis, which indicated that patient aged more than 60 years was a risk factor while the central venous access with Certofix[®] was associated with an increased rate of success (Table 3).

Discussion

To our knowledge, this study involved the largest reported number of subclavian vein punctures performed by the same operator. In contrast to prior studies of failure of subclavian vein puncture,⁵⁻⁷ in this investigation, all of the patients underwent subclavian vein catheterization performed by the same experienced operator, avoiding any potential influence of differences in the technical skill levels of various operators. The success rate in our study was very high. In addition, incidences of hemothorax, ectopic catheterization and other complications were lower in this study than the other literature reported.^{4,8}

Table 3 Multivariate analysis of risk factors for failure of subclavian vein catheterization.

Factors	OR	95% CI for OR	<i>p</i>
Age > 60 years	1.045	1.024–1.067	0.001
Central venous access with Certofix [®]	0.570	0.363–0.896	0.015
Constant	0.006		0.001

We used Forward LR of logistic regression in the multivariate analysis.

In our study, we found that aged more than 60 years was a risk factor for failure of the subclavian vein puncture. We speculated that it might be related to the deterioration of venous vessels after aging. Takeyama H et al.⁵ reported that a low BMI was associated with failure of the subclavian vein puncture but not age. Lefrant et al.⁷ reported that more than one venipuncture and age 77 years or more were risk factors for complications of subclavian vein catheterization in critically ill patients. Another study had shown that prior major surgery in the region and BMI was associated with failure of the subclavian vein puncture,⁶ but such association was not observed in our study. In the univariate analysis, there was a significant difference about preoperative hemoglobin in two groups but there was no significant correlation between preoperative hemoglobin and failure of subclavian vein puncture in the multivariate analysis.

We found that the central venous access with Certofix[®] was associated with an increased rate of success. We guessed it was related to the length of the needle. The length of the puncture needle with Certofix[®] was 7 cm and 6.35 cm from Arrow. A shorter needle might not get into the blood vessels in some patients. However, there was no evidence in the literature. In the future, a randomized controlled study will be needed to confirm this conclusion.

In recent years, the number of subclavian and axillary vein punctures performed with ultrasound guidance has markedly increased. However, ultrasound-guided sub-

clavian vein puncture requires special technical training.^{9,10} Therefore, this procedure is difficult to use, especially in developing countries where ultrasound cannot be used routinely; moreover, there remains controversy regarding the use of ultrasound for subclavian and axillary vein punctures. Certain studies have suggested that ultrasound is not helpful for these procedures,^{6,11} whereas other reports have argued that ultrasound guidance is beneficial.^{12–15} In the cases involving failure of subclavian vein puncture, we chose ultrasound-guided axillary or internal jugular vein puncture and these might show the advantages of ultrasound-guided punctures.

Unsurprisingly, this study has shortcomings. First, this investigation is a retrospective study, and certain data, such as hemoglobin and hematocrit levels, were obtained within one month prior to vein puncture. Therefore, this study could not definitively establish positive associations between failure of subclavian vein puncture and these two test levels (hemoglobin and hematocrit); future prospective investigations are required to assess these associations. Second, we were unable to determine volume capacities of patients, but low blood volume may have been an important reason for failure of the subclavian vein puncture.

Conclusion

This study has demonstrated that patient aged more than 60 years was a risk factor for failure of subclavian vein catheterization while the central venous access with Certofix[®] was associated with an increased rate of success.

Compliance with ethical guidelines

Our study was approved by the Medical Ethical Committee of Peking University Cancer Hospital.

Conflicts of interest

The authors declare no conflicts of interest.

References

1. Merrer J, Jonghe BD, Golliot F, et al. Complications of femoral and subclavian venous catheterization in critically ill patients: a randomized controlled trial. *JAMA*. 2001;286:700–7.
2. Camkiran Firat A, Zeyneloglu P, Ozkan M, et al. A randomized controlled comparison of the internal jugular vein and the subclavian vein as access sites for central venous catheterization in pediatric cardiac surgery. *Pediatr Crit Care Med*. 2016;17:e413–9.
3. Parienti JJ, Mongardon N, Mégarbane B, et al. Intravascular complications of central venous catheterization by insertion site. *N Engl J Med*. 2015;373:1220–9.
4. McGee DC, Gould MK. Preventing complications of central venous catheterization. *N Engl J Med*. 2003;348:1123–33.
5. Takeyama H, Taniguchi M, Sawai H, et al. Limiting vein puncture to three needle passes in subclavian vein catheterization by the Infraclavicular approach. *Surg Today*. 2006;36:779–82.
6. Mansfield PF, Hohn DC, Fornage BD, et al. Complications and failures of subclavian-vein catheterization. *N Engl J Med*. 1994;331:1735–8.
7. Lefrant JY, Muller L, De La Coussaye JE, et al. Risk factors of failure and immediate complication of subclavian vein catheterization in critically ill patients. *Intensive Care Med*. 2002;28:1036–41.
8. Wong AV, Arora N, Olusanya O, et al. Insertion rates and complications of central lines in the UK population: A pilot study. *J Intensive Care Soc*. 2018;19:19–25.
9. Lamperti M, Bodenham AR, Pittiruti M, et al. International evidence based recommendations on ultrasound-guided vascular access. *Intensive Care Med*. 2012;38:1105–17.
10. Frykholm P, Pikwer A, Hammarskjöld F, et al. Clinical guidelines on central venous catheterisation Swedish Society of Anaesthesiology and Intensive Care Medicine. *Acta Anaesthesiol Scand*. 2014;58:508–24.
11. Griswold-Theodorson S, Farabaugh E, Handly N, et al. Subclavian central venous catheters and ultrasound guidance: policy vs practice. *J Vasc Access*. 2013;14:104–10.
12. Gualtieri E, Deppe SA, Sipperly ME, et al. Subclavian venous catheterization: greater success rate for less experienced operators using ultrasound guidance. *Crit Care Med*. 1995;23:692–7.
13. Fragou M, Gravvanis A, Dimitriou V, et al. Real-time ultrasound-guided subclavian vein cannulation versus the landmark method in critical care patients: a prospective randomized study. *Crit Care Med*. 2011;39:1607–12.
14. Lin CP, Wang YC, Lin FS, et al. Ultrasound-assisted percutaneous catheterization of the axillary vein for totally implantable venous access device. *Eur J Surg Oncol*. 2011;37:448–51.
15. Kim EH, Lee JH, Song IK, et al. Real-time ultrasound-guided axillary vein cannulation in children: a randomised controlled trial. *Anaesthesia*. 2017;72:1516–22.