ORIGINAL ARTICLE

Ultrasonography-guided central venous catheterisation in haematological patients with severe thrombocytopenia

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Background. Cannulation of the internal jugular vein (CVC) is a blind surface landmark-guided technique that could be potentially dangerous in patients with very low platelet counts. In such patients, ultrasonography (US)-guided CVC may be a valid approach. There is a lack of published data on the efficacy and safety of urgent US-guided CVC performed in haematological patients with severe thrombocytopenia.

Materials and methods. We retrospectively studied the safety of urgent CVC procedures in haematological patients including those with severe thrombocytopenia (platelet count $<30\times10^9$/L). From January 1999 to June 2009, 431 CVC insertional procedures in 431 consecutive patients were evaluated. Patients were included in the study if they had a haematological disorder and required urgent CVC insertion. Patients were placed in Trendelenburg's position, an 18-gauge needle and guide-wire were advanced under real-time US guidance into the last part of the internal jugular vein; central venous cannulation of the internal jugular vein was performed using the Seldinger technique in all the procedures. Major and minor procedure-related complications were recorded.

Results. All 431 patients studied had haematological disorders: 39 had severe thrombocytopenia, refractory to platelet transfusion (group 1), while 392 did not have severe thrombocytopenia (group 2). The general characteristics of the patients in the two groups differed only for platelet count. The average time taken to perform the procedure was 4 minutes. Success rates were 97.4% and 97.9% in group 1 and group 2, respectively. No major complications occurred in either group.

Discussion. US-guided CVC is a safe and effective approach in haematological patients with severe thrombocytopenia requiring urgent cannulation for life support, plasma-exchange, chemotherapy and transfusion.

Keywords: central venous catheterisation, ultrasound, Seldinger technique, low platelet count, haematological malignancy.

Introduction

Cannulation of the internal jugular vein (CVC) is a procedure commonly performed for long-term therapies in haematological patients needing chemotherapy, apheresis and life support treatments[1-3]. In patients with effective haemostasis, CVC is usually performed with a blind, surface landmark-guided (sternocleidomastoid muscle, clavicle, cricoid) technique. The most common complications associated with this procedure are bleeding, haematoma, arterial puncture and pneumothorax; damage to neural structures such as phrenic nerve and brachial plexus as well as low compliance and long procedural time have been reported less commonly[4,5].

Ultrasonography (US)-guided CVC is an important, safe and cost-effective imaging-based technique, used in different emergency settings for high-risk patients. There have been several prospective randomised trials suggesting that the use of US is associated with a reduction in complication rate and an improved first-pass success when cannulating the internal jugular vein, because US allows direct visualisation of the vein's orientation, dimension and relation with surrounding structures[4-7].

We here report clinical outcomes in a retrospective study on urgent US-guided CVC procedures in high-risk haematological patients with severe thrombocytopenia refractory to platelet infusion.

Materials and methods

Study design

This was a retrospective study on the safety of urgent CVC insertion procedures in haematological patients with

low platelet counts admitted to the Haematology Unit of our Institution over a period of 10 years.

Study population

All the patients included in the study had an underlying haematological disease requiring urgent US-guided CVC. Our population was divided into two groups on the basis of platelet count: group 1 patients had persistent, transfusion-refractory, severe thrombocytopenia with a platelet count below 30×10^9/L and were at high risk of post-procedural bleeding whereas group 2 patients had a baseline or post-transfusion platelet count above 30×10^9/L and were considered at low risk of bleeding. The indications for urgent CVC in this study were the need to deliver chemotherapy, transfusions, parenteral nutrition, plasma-exchange or intensive life-support therapy. Operators included one thoracic surgeon and one nurse with specific experience in the field.

Patients were included in the analysis only if the following information was available: time taken to perform the US-guided CVC, first pass success, number of needle punctures, and complications. All patients were followed-up for at least 1 week after the procedure. At follow-up, patients underwent a clinical examination, the catheter exit site was dressed and the catheter was flushed with a heparinised solution.

Complications

Complications were defined as major or minor and early (occurring during or immediately after the US-guided CVC procedure) or late (occurring within 1 week after the procedure).

Early complications included vasovagal hypotension, vein puncture, haematomas (minor complications), and post-procedural bleeding, pneumothorax, haemothorax and puncture of an artery or nerve (major complications). Late complications were occlusion/malfunction, catheter-related blood stream infections (minor complications), and vein thrombosis and pulmonary embolism (major complications).

Ultrasound-guided central venous catheterisation

All catheters were placed by one thoracic surgeon with experience of more than 50 US-guided CVC and landmark cannulation procedures in order to minimise the risk of operator-related complications and failures[8,9]. The site of placement of the central venous catheter was identified by localisation of the vein and evaluation of specific risk factors (emphysema, coagulation disorders, and special anatomical conditions) in each patient[4,10].

Following standard aseptic techniques to prepare the skin of the anterior and lateral surface of the neck, patients were placed in the Trendelenburg position, with the head rotated towards the opposite side and local anaesthesia was administered. A standard Seldinger technique was used for cannulation[11] of the internal jugular vein. The ultrasound probe used was a "Prisma-Diasonics" (Sonotron/Diasonics, Les Ulis, France) instrument, with a linear transducer (10 MHz). The longitudinal axis of the internal jugular vein and its relationship with other anatomical structures were identified with the aid of Valsalva manoeuvres, which increase the diameter of the veins. Under US-guidance (real-time B mode) an 18-gauge needle and a guide-wire (0.36 inches) were introduced, minimising damage to the surrounding structures. Entry into the vein was confirmed by visualising indentation on the anterior wall of the vein followed by blood in the syringe and absence of resistance or pain after flushing a saline solution. The placement of the guide-wire in the internal jugular vein was confirmed by rescanning the vein. Double lumen 7 Fr and 11 Fr venous catheters were placed for chemotherapy and apheresis, respectively. The day after the procedure, a 3-day course of antibiotic prophylaxis was started with ceftriaxone at the dose of 1 g/day. Antithrombotic prophylaxis with low molecular weight heparin (2,850 IU anti-Xa in patients ≤70 kg or 3,800 IU anti-Xa in patients >70 kg) was given for 4 weeks. Patients with a platelet count $<30\times10^9$/L 1 hour before the procedure received a transfusion of two units of platelets obtained from apheresis. Each platelet unit administered contained approximately 3.0×10^{11} platelets.

Informed consent and statistics

All patients included in the study signed informed consent before undergoing the procedure. The present study was approved by the safety Institutional Review Board of "P. Giaccone" University Hospital, Palermo (Italy).

Demographic data and clinical features were analysed using descriptive methods. All data are expressed as means ± standard deviations (SD) or as percentages. Differences between the two groups at baseline were analysed with Student's *t*-test and the chi-square test with Yates' correction for categorical variables.

Results

The patients' characteristics and clinical data are summarised in Table I. Over a period of 10 years (from January 1999 to June 2009), 431 US-guided CVC were performed in 431 haematological patients, including 39 (group 1) with severe thrombocytopenia ($<30\times10^9$/L) who were refractory to platelet transfusions. The median platelet count before and after platelet transfusion in this group was 15×10^9/L and 29×10^9/L, respectively; 34 patients had acute leukaemia and five had idiopathic thrombocytopenia. In the other 392 patients (group 2), the median platelet count (at baseline or after platelet infusion) was 90×10^9/L. There were no significant

Table I - Patients' baseline characteristics.

Patients' characteristics	With severe thrombocytopenia (n=39)	Without severe thrombocytopenia (n=392)	P value
Male/female, n.	23/16	229/163	0.9464
Age, years	53 (18-81)	50 (18-83)	0.7977
Body mass index	19	22	0.1113
Haemoglobin (g/L), median (range)	100 (50,0-130,0)	110 (70,0-160)	0.3996
White blood cell count ($\times 10^9$/L), median (range)	3 (0,5-50,0)	3,9(0,4-49)	0.4107
Platelet count ($\times 10^9$/L),median (range)	15 (10-29)	90 (65-120)	0.0001
Chemotherapy for acute haematological malignancies, n. (%)	27 (69, 2%)	272(69, 4%)	0.9838
Need for plasma exchanges, n (%)	0 (0%)	22 (5, 6%)	0.2445
Intensive therapy or transfusion requirement, n (%)	12 (30, 8%)	98 (25%)	0.5515

differences between the two groups in terms of gender, age, body mass index, haemoglobin levels or white blood cell count.

Outcomes including success rates, number of needle passes, time taken to perform the procedure and early complications are reported in Table II. The average time taken to perform the procedure was 4 minutes in both groups. In seven cases, all in group 2, the procedure was interrupted (because of vasovagal hypotension in 5 patients and collapse of central vein in 2 patients). The rate of single needle punctures was 100% (39/39) in group 1 and 95.9% (376/392) in group 2 (P =0.38). The causes of two (or more) needle punctures in group 2 included collapse of the central vein during introduction of the needle. The success rate was 97.4% in group 1 (38/39) and 97.9% (384/392) in group 2 (P =0.57).

An anatomical variation of the site or orientation of the internal jugular vein was found in 4.7% of all cases (2 in group 1 and 8 in group 2).

There were no infections or thrombosis, arterial punctures with bleeding or pneumothorax, or other major, early or late complications. The minor complication rate was 2.6% (1/39) in group 1 (1 haematoma) and 3.0% (12/392) in group 2 (7 cases of subcutaneous haematomas and 5 cases of vasovagal hypotension) (P =0.10). There was one post-operative catheter dislocation in each group.

Discussion

CVC is needed for long-term intravenous therapy in patients with haematological disorders. A challenging clinical scenario can occur when urgent treatment is necessary in patients at high risk of bleeding because of an underlying haematological disorder with a very low platelet count, refractory to platelet transfusion (defined as an unsatisfactory post-transfusion platelet increment[12]). Furthermore, patients with acute leukaemia are particularly vulnerable to infections. Traditionally, the site of central venous access is guided by anatomical landmarks such as bony prominences, muscle surfaces, and arterial pulsations. This "blind" approach to the central veins assumes anatomical uniformity, does not account for the possibility of occlusions, and depends on correct discernment of the relationship among multiple anatomical landmarks. For these reasons, the procedure is associated with a relatively high incidence of complications, related to first pass failure, arterial punctures[13] or inexperience of the operator[8,9,14].

In comparison to standard CVC, US-guided CVC is more feasible and offers various advantages (ease of vein identification, a shorter duration of the procedure) which, together with a higher rate of success and decreased incidence of complications, make the latter preferable to the former, especially in high-risk patients[4,6,15]. Moreover, patients' compliance with this technique is high.

Table II - Success rate and complication at the time or immediately after CVC insertion.

Outcome	With severe thrombocytopenia (n=39)	Without severe thrombocytopenia (n=392)	P value
Average time for the CVC, min.	4.5	4.6	0.6545
Single needle puncture rate, n (%)	39 (100%)	376 (95, 9%)	0.3813
Major complications, n (%)	0	0	/
Minor complications, n (%) (haematoma and vasovagal hypotension)	1 (2, 6%) (haematoma)	12 (3, 0%) (7 haematoma, 5 vagal hypotension)	1.0000
Successful, n (%)	38 (97, 4%)	384 (97, 9%)	0.5777
Catheter dislocation, n (%)	(2, 6%)	1 (0, 2%)	0.1730
Interrupted CVC, n (%)	0	7 (1, 7%)	0.4877
Anatomic variations, n (%)	2 (5, 1%)	8 (2, 0%)	0.2265

Our observations confirm those from a previous larger study performed in cancer patients in whom this technique was also used in a subset of haematological patients with very low platelet counts, without any mechanical complication or major bleeding[16]. The authors did not, however, adopt any antithrombotic or antibiotic prophylaxis and reported some cases of thrombosis of the internal jugular vein and infections of the central venous catheters. In our study, the administration of antibiotics for 3 days after the procedure and low molecular weight heparin at prophylactic doses for up to 4 weeks after CVC enabled complete avoidance of these kinds of complications in all patients.

We have shown that US-guided CVC may be efficacious and safe for patients with haematological disorders, even in urgent clinical settings. In addition, we highlight that the catheter was inserted into 39 patients with very low platelet counts secondary to acute leukaemia and idiopathic thrombocytopenia, without any major complications including infections. Although data from other institutions might differ from ours, we think that the results of the present study are interesting because they have been collected from a series of vulnerable patients prospectively investigated over a 10-year period. The main limitations of this study are the absence of a control group and the fact that it was conducted in a single institution. Nevertheless, this cohort study was performed in a representative population and is especially relevant as it concerns life-threatening clinical conditions associated with a high risk of bleeding and infectious complications.

Conclusions

US-guided CVC seems to be the most suitable technique for catheter insertion in high-risk patients. In our study of haematological patients there were no significant differences between patients with severe thrombocytopenia and patients with normal to low platelet count in terms of success rate (97.4% *vs* 97.9% respectively) and incidence of complications. Furthermore the administration of antibiotic and antithrombotic prophylaxis was effective in avoiding thrombosis and catheter infections in this context. In conclusion, US-guided CVC offers an easy, safe and rapid solution in high-risk haematological patients requiring urgent treatments.

The Authors declare no conflicts of interest.

References

1) Zimmermann JJ, Strauss RH. History and current application of intravenous therapy in children. Pediatr Emerg Care 1989; **5**: 120.
2) Scott WT, Bergamini MB. Long term venous access: indications and choice of site and catheter. Semin Vasc Surg 1997; **10**: 130-4.
3) Newman KA, Reed WP, Schimpff SC, et al. Hickman catheters in association with intensive cancer chemotherapy. Support Care Cancer 1993; **1**: 92-7.
4) Lameris JS, Post PJ, Zonderland HM, et al. Percutaneous placement of Hickman catheters: comparison of sonographically guided and blind techniques. Am J Radiol 1990; **155**: 1097-9.
5) Cajozzo M, Cocchiara G, Greco G, et al. Comparison of central venous catheterization with and without ultrasound guide. Transfus Apher Sci 2004; **31**: 199-202.
6) Mallory DL, McGee WT, Shawker TH. Ultrasound guidance improves the success rate of internal jugular vein cannulation. Circulation 1993; **87**: 1557-62.
7) Cajozzo M, Cocchiara G, Greco G, et al. Ultrasound (US) central venous catheterization of internal jugular vein on over 65 years old patients versus blind technique. J Surg Oncol 2004; **88**: 267-8.
8) Abraham E, Shapiro M, Podolsky S. Central venous catheterization in the emergency setting. Crit Care Med 1983; **11**: 515-7.
9) Bo-lin GW, Anderson DJ, Anderson KC. Percutaneous central venous catheterization performed by medical house officers: a prospective study. Cathet Cardiovasc Diagn 1982; **8**: 23-9.
10) Downie AC, Reidy JF, Adam AN. Short communication: tunnelled central venous catheter insertion via the internal jugular vein using a dedicated portable ultrasound device. Br J Radiol 1996; **69**: 178-81.
11) Seldinger SI. Catheter replacement of the needle in percutaneous arteriography: a new technique. Acta Radiol 1953; **39**: 368-76.
12) Hod E, Schwartz J. Platelet transfusion refractoriness. Br J Haematol 2008; **142**: 348.
13) Denys BG, Uretsky BF. Anatomical variations of internal jugular vein location: impact on central venous access. Crit Care Med 1991; **19**: 1516-9.
14) Sznajder JL, Zveibil FR, Bitterman H. Central vein catheterisation. Arch Intern Med 1986; **146**: 259-61.
15) Denys BG, Uretsky BF, Reddy PS. Ultrasound assisted cannulation of the internal jugular vein. Crit Care Med 1991; **87**: 1557-62.
16) Cavanna L, Civardi G, Vallisa D, et al. Ultrasound-guided central venous catheterization in cancer patients improves the success rate of cannulation and reduces mechanical complications: a prospective observational study of 1,978 consecutive catheterizations. World J Surg Oncol 2010; **8**: 91.

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