

# Real-Time Ultrasonographically-Guided Internal Jugular Vein Catheterization in the Emergency Department Increases Success Rates and Reduces Complications: A Randomized, Prospective Study

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**Study objective:** We compare real-time ultrasonographic guidance and the traditional landmark technique for the insertion of internal jugular vein catheters in an emergency department (ED) setting.

**Methods:** This was a prospective, randomized, clinical study performed in a tertiary ED between August 2003 and May 2005 on patients requiring central venous access. Ultrasonographically guided catheters were inserted under real time using the Sonosite ultrasonographic system with a 10 to 5 MHz 38-mm linear array transducer. Standardized data were collected on operator experience, method of insertion, reason for central venous access, and comorbidities. Outcome measures included successful insertion of an internal jugular vein catheter, number of attempts, access times, and complications.

**Results:** One hundred thirty patients were enrolled. Cannulation of the internal jugular vein was successful in 61 of 65 patients (93.9%) using ultrasonography and in 51 of 65 patients (78.5%) using the landmark technique, a significant difference of 15.4% ( $P=.009$ , 95% confidence interval [CI] 3.8% to 27.0%). Fifty of 61 (82.0%) of the successful ultrasonographically guided catheters were inserted on the first attempt compared with 36 of 51 (70.6%) of the successful landmark catheters. Mean access times to venipuncture and successful insertion were 138 and 281 seconds by ultrasonographic guidance and 132 and 271 seconds by the landmark technique. There was a 10.8% complication rate, with 11 complications (16.9%) in the landmark group and 3 (4.6%) in the ultrasonographic group, a difference of 12.3% (95% CI 1.9% to 22.8%).

**Conclusion:** Ultrasonographically guided internal jugular vein catheterization in the ED setting was associated with a higher successful insertion rate and a lower complications rate. [Ann Emerg Med. 2006;48:540-547.]

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## SEE RELATED EDITORIAL, P. 548.

### INTRODUCTION

#### Background

Central venous catheterization is a common and important procedure in the emergency department (ED). It allows resuscitation for intravascular fluid depletion and access for vasoactive medications and antibiotics, and it provides a means for hemodynamic monitoring and pacing.<sup>1,2</sup> At times, it may be the only form of intravenous access. The internal jugular, subclavian, and femoral veins are commonly used for central

venous access. Femoral vein catheterization has always been an attractive method of obtaining central venous access in the ED because it is possible in the vast majority of patients, is suitable for many indications, and is associated with a low complication rate during insertion. However, disadvantages include the inability to perform invasive hemodynamic monitoring and the higher risks of thromboembolic and infectious complications.<sup>3</sup> Therefore, central venous access by the internal jugular vein or subclavian vein may be preferred in the ED setting.

However, there are well-documented risks and complications associated with internal jugular vein and subclavian vein

### Editor's Capsule Summary

#### *What is already known about this topic*

Ultrasonographic guidance of central vein catheter placement is associated with higher success rates and lower complication rates compared with blind techniques.

#### *What question this study addressed*

This randomized, prospective study with emergency department patients focused on internal jugular vein cannulation and compared success rates, complications, and procedural times using ultrasonographic guidance versus the traditional landmark technique.

#### *What this study adds to our knowledge*

In 130 patients, ultrasonographic guidance was associated with a 15% higher success rate (94% versus 79%) of internal jugular vein cannulation compared to the traditional landmark technique. When ultrasonographic guidance was used, experienced and inexperienced operators achieved high, nearly equivalent success rates, whereas inexperienced operators were 12% less successful than experienced operators in the absence of ultrasonographic guidance. Complications (hematoma, carotid artery puncture, and pneumothorax) were also lower in the ultrasonographic group (17% versus 5%).

#### *How this might change clinical practice*

"Best practice" for placement of internal jugular lines involves use of ultrasonographic guidance. Efforts should be made to make ultrasonographic guidance of internal jugular lines the standard practice within emergency medicine.

catheterization, especially in the urgent or emergency situation.<sup>1,2</sup> Complications for internal jugular vein catheters include carotid artery puncture, hematoma, pneumothorax, brachial plexus injury, and hemothorax.<sup>3</sup> The complication rate for central venous catheters (subclavian, internal jugular, femoral) inserted using the traditional landmark technique ranges from 0.5% to 10%.<sup>2,4,5</sup> In ED patients specifically, the mechanical complications rate (pneumothorax, hematoma, line misplacement, hemothorax) has been quoted as between 10% and 15%.<sup>5</sup> Unsuccessful insertion may occur in up to 20% of cases.<sup>4</sup> The rates vary, depending on operator experience and patient comorbidities such as coagulopathy and hemodynamic instability.<sup>2,6</sup> Anomalies in anatomy may cause the operator to pass the needle in an inappropriate direction, or the landmark method may fail if the vein has thrombosed.<sup>6</sup>

### Importance

Studies in anesthetic, cardiac, and intensive care settings have shown that ultrasonographic guidance for the insertion of

central lines, particularly through the internal jugular vein, can lead to a decrease in the number of attempts to successful puncture, a decrease in the rate of complications, and in some cases, a faster insertion time.<sup>6-15</sup> However, there are only limited studies in the literature about ultrasonographically guided central venous access in the ED.<sup>1,16-18</sup> One study involving catheterization of the internal jugular vein suggested that single-needle-pass punctures and successful venipunctures were improved with ultrasonography, but the study was not randomized and the sample size was small.<sup>17</sup> The other larger study by Miller et al,<sup>1</sup> based in the ED, was not specific for internal jugular vein catheterization.

### Goals of This Investigation

The purpose of this study was to determine whether real-time ultrasonographic guidance could improve the success rate, decrease the number of attempts and time to successful puncture, and decrease the number of complications compared to the landmark technique for the insertion of internal jugular vein catheters in an ED setting.

## MATERIALS AND METHODS

### Study Design and Setting

This was a prospective, randomized, clinical trial performed in the ED of a major tertiary teaching hospital with approximately 36,000 presentations a year. The study was approved by the hospital's ethics committee.

### Selection of Participants

All patients presenting to the ED between August 2003 and May 2005 who required central venous access as part of their treatment were considered for the study. Patients were enrolled by the emergency physician or registrar treating or supervising the patient. The sample was not consecutive (Figure 1).

Indications for central venous access in the ED included difficult peripheral venous access, need for invasive hemodynamic monitoring, delivery of inotropic medications or antibiotics, delivery of fluids and blood when no other access was available, and temporary internal pacing. All patients were older than 18 years.

The exclusion criteria were trauma patients in whom the cervical spine could not be cleared clinically or radiologically before line insertion and patients with severe coagulopathy (consistent history and active bleeding) that could not be corrected with platelets, fresh frozen plasma, or other blood products.

Informed consent was obtained from the subject or relative(s) before enrollment in the study. Patients were then randomized to one of the 2 insertion techniques by computer-generated block randomization. Allocation assignments were concealed in serially numbered opaque sealed envelopes. The operator and patient became aware of the insertion technique only after enrollment.

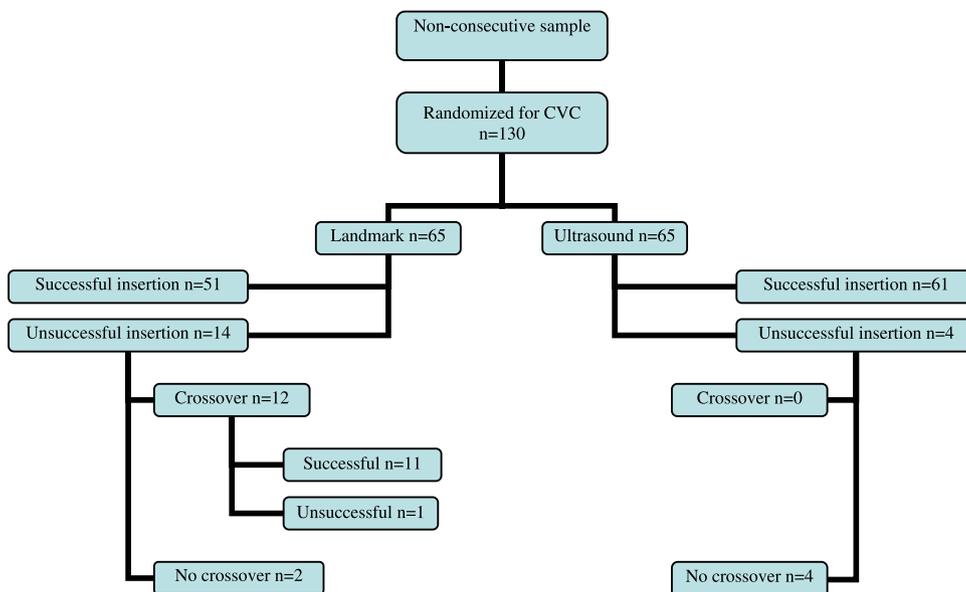


Figure 1. CONSORT diagram. CVC, Central venous catheterization.

**Interventions**

Operators were either emergency physicians or registrars (trainees of the Australasian College for Emergency Medicine, postgraduate year 3 or above) working in the ED. The operator for each case was the physician or registrar who enrolled the patient. Experienced operators were defined as those who had successfully performed more than 25 traditional landmark internal jugular vein catheterizations without supervision, and inexperienced operators as those who had performed fewer than 25 traditional landmark internal jugular vein catheterizations. There were 13 operators, with 5 experienced and 8 inexperienced. Before commencement of the study, operators participated in a minimum 2-hour education program outlining the landmark technique, the use of the ultrasonographic machine in locating the internal jugular vein, and subsequent insertion of the catheter under real-time ultrasonographic guidance.

The landmark technique was performed using the central, anterior, or posterior approach, depending on operator experience and preference.

Ultrasonographically guided internal jugular vein catheters were inserted using the portable, software-controlled, SonoSite ultrasonographic system with a 10-5 MHz 38-mm linear array transducer (SonoSite 180; SonoSite Inc., Bothell, WA). To maintain a sterile field, the lead and probe were cleaned with antiseptic solution. The probe was then covered with a sterile glove and gel. After the patient was placed in the Trendelenburg position and the neck sterilized with antiseptic, the probe was placed perpendicular to the vessels, at the apex of the triangle between the 2 heads of the sternocleidomastoid muscle and the clavicle. The internal jugular vein and carotid artery were best visualized in the transverse plane, with the vein recognized by its larger size and easy compressibility. The probe was placed so

that the internal jugular vein was visualized in the center of the ultrasonographic screen (Figure 2), and the needle was then introduced at the center of the probe at a 30- to 40-degree angle to the frontal plane toward the ipsilateral nipple. On the ultrasonographic screen, the needle could be seen either puncturing the vein under real time or compressing the vessel. Once puncture of the vein occurred, the standard Seldinger technique for inserting central venous catheters was followed.

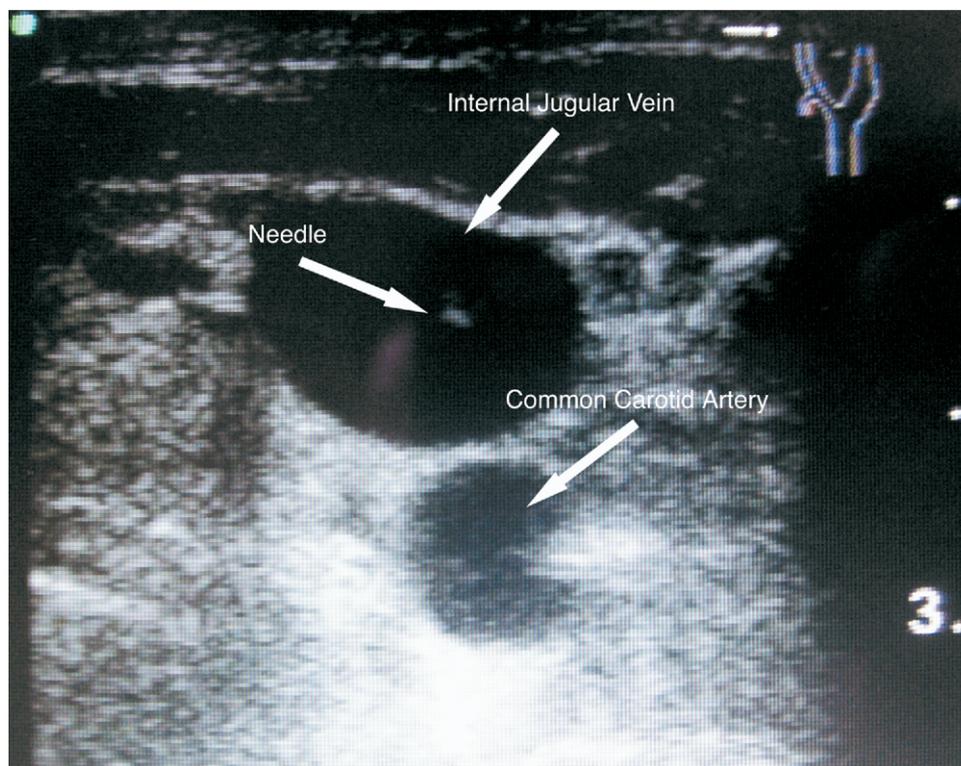
The position of all central venous catheters was confirmed by chest radiography at the conclusion of the procedure.

If the initial method was unsuccessful after a maximum of 3 attempts, provision was made in the study for crossover to the other technique. Again, 3 attempts could be made with the second technique. If both methods were unsuccessful or crossover did not occur, then alternative access was obtained and documented. Alternative access sites included the contralateral internal jugular vein, subclavian vein, or femoral vein.

**Methods of Measurement and Data Collection and Processing**

At the end of the procedure, the operator recorded the data on a preformatted data collection sheet. Data included patient details, operator and level of experience, method of insertion, which approach if the landmark method was used, reason for insertion of the central line, comorbidities (obesity, coagulopathy, previous neck surgery or central line, hypotension, and tachycardia), number of attempts, access times, and complications.

The procedure was considered successful if the internal jugular vein was cannulated and resulted in successful aspiration of blood. The procedure was considered a failure if the operator was unable to perform cannulation of the internal jugular vein



**Figure 2.** Transverse view of right internal jugular vein.

after 3 attempts. Failure was due to either inability to locate or puncture the internal jugular vein or inability to feed the guidewire or catheter. An attempt was defined as the introducer needle's entry into the skin and its removal from the skin.

For each technique, 2 access times were recorded: the time to initial flash of blood (start to flash time) and the time to successful insertion of the central venous catheter (start to line working time). Start to flash time for the landmark technique commenced when the 23-gauge finder needle was introduced to locate the internal jugular vein and ended with puncture by the larger introducer needle. Start to line working time for the landmark technique was measured from the commencement of localization of the vein to successful cannulation of the vein, as indicated by successful aspiration of blood from the distal lumen. Start to flash time for the ultrasonographic method commenced when the ultrasonographic probe was placed on the neck to locate the internal jugular vein and ended with puncture by the introducer needle; a finder needle was not used. Start to line working time for the ultrasonographic method was measured from the commencement of localization of the vein to successful cannulation of the vein. Timing was performed by an assistant (another emergency physician or registrar) using a digital stopwatch.

### Outcome Measures

The main outcome measure was the successful insertion of an internal jugular vein central venous catheter. Secondary outcome measures included the number of attempts; access

times; and complications such as hematoma, pneumothorax, carotid artery puncture, or nerve injury.

### Primary Data Analysis

The outcome measures of successful insertion and complications were analyzed using the  $\chi^2$  test with 1 degree of freedom. For the outcome measures of access times 1 and 2, a 2-sample *t* test was performed. The statistics package used for the analyses was the MINITAB Student release 12.1 (MINITAB, State College, PA).

Using a predicted successful insertion rate, based on previous literature, of 85% for the landmark technique and 95% with ultrasonographic guidance ( $P=.05$ ; 80% power), the estimated sample size was 360. However, given the evidence in other critical care settings for the benefits of ultrasonographically guided central venous access, an interim analysis, based on the primary outcome of successful cannulation, was planned once study numbers over 100 were obtained.  $P<.01$  was chosen as the cutoff level for stopping the trial early.

## RESULTS

### Characteristics of Study Subjects

One hundred thirty patients were enrolled in the study; 65 (50%) patients were randomized to the landmark technique and 65 (50%) patients to the ultrasonographic method. The clinical variables and reasons for insertion of the internal jugular vein catheter in both groups are summarized in Tables 1 and 2.

**Table 1.** Clinical variables for each group (n=130).

Clinical Variables	Landmark Group, N=65	Ultrasonographic Group, N=65
Mean age, y	51 (Min 22, max 88)	58 (Min 20, max 91)
Men	36	39
Obesity	14	19
Coagulopathy	6	14
Previous CVC	26	16
Intubated	13	20
BP <90	22	29
PR >120	13	19
Experienced operator	32 (49.2%)	29 (44.6%)

BP, Blood pressure (mmHg); PR, pulse rate (beats/min).

**Table 2.** Reasons for insertion for each group (n=130).

Reason for Insertion	Landmark Group, N=65	Ultrasonographic Group, N=65
Difficult venous access	32	28
Delivery of antibiotics	22	18
Delivery of inotropes	16	23
Delivery of fluids/bloods	21	26
Hemodynamic monitoring	33	45

**Main Results**

The statistical analysis of success rates assumes patients were a simple random sample from the population of potential patients. Given the potential for physicians to induce a cluster sampling effect, the design effect applying to the comparison of ultrasonography and landmark methods was calculated at 1.2. Although this calculation is slightly above the ideal of 1.0, it is thought to be reasonably attributable to random sampling effects, and therefore the data are deemed to be consistent with a simple random sample.

The main outcome measures for each group are summarized in Table 3. Fifty-one of 65 (78.5%) internal jugular vein catheters were successfully inserted by the landmark technique. Sixty-one of 65 (93.9%) internal jugular vein catheters were successfully inserted under real-time ultrasonographic guidance. Our study found a significant difference of 15.4% in successful insertion with ultrasonographic guidance ( $\chi^2=6.45, df=1, P=.009, 95\%$  confidence interval [CI] 3.8% to 27.0%). The average number of attempts resulting in successful insertion was 1.6 for the landmark technique and 1.3 for ultrasonographic guidance.

The mean start to flash time for the landmark technique was 132 seconds (median 55 seconds); for ultrasonography, it was 138 seconds (median 58 seconds). The mean start to line working time for the landmark technique was 271 seconds (median 180 seconds); for ultrasonography, it was 281 seconds (median 198 seconds).

There were 14 (10.8%) complications in the study: 11 in the landmark group (16.9% complication rate) and 3 in the ultrasonographic group (4.6% complication rate). A difference

of 12.3% in favor of fewer complications with the ultrasonographic method was found (95% CI -1.9% to -22.8%). In the landmark group, there were 7 hematomas, 4 carotid artery punctures, and 1 pneumothorax. In the ultrasonographic group, there were 2 hematomas, 1 carotid artery puncture, and no pneumothoraces.

Table 4 summarizes operator experience and success rates for both landmark and ultrasonographic methods. Experienced operators successfully inserted an internal jugular vein catheter in 54 of 61 (88.5%) cases compared with 58 of 69 (84.0%) cases in the inexperienced group (95% CI 7.3% to 16.2%). Operator effect was examined by assessing variation in success across operators ( $P>.9$ ) and variation in the comparison of success rates between ultrasonographic and landmark methods across operators ( $P>.9$ ) by using unconditional logistic regression. In neither instance was there any suggestion of an operator effect on the probability of successful insertion. The catheter was inserted on the first attempt in 46 of 54 (85.2%) patients in the experienced group and 40 of 58 (69.0%) patients in the inexperienced group. A difference of 16.2% (95% CI 1.0% to 31.4%) was observed.

For the initial method, there were 18 unsuccessful internal jugular vein catheterizations, 14 in the landmark group and 4 in the ultrasonographic group. These unsuccessful catheterizations were predominantly due to an inability to locate the vein.

Provision was made in the study for crossover to the other technique on the ipsilateral side of the neck, depending on complications and patient cooperation. Of the initial unsuccessful catheters, crossover occurred in 12 of 14 patients in the landmark group and 0 of 4 patients in the ultrasonographic group. Crossover was not attempted in 2 of 14 failed landmark cases because the guidewire was not able to be fed through the vein. Crossover was not attempted in the 4 failed ultrasonographic cases, because the internal jugular vein was poorly visualized or the guidewire was unable to be fed through the vein. With ultrasonographic guidance as the second method, there were 11 of 12 internal jugular vein catheters successfully inserted. With ultrasonographic guidance, the mean number of attempts was 1.1, start to flash time 104 seconds, and start to line working time 229 seconds. There were no complications. For the failed catheter using both methods on the ipsilateral internal jugular vein, the vein was not able to be located.

For the unsuccessful internal jugular vein catheterizations, access was obtained in the contralateral internal jugular, subclavian, external jugular, or femoral vein.

**LIMITATIONS**

There were several limitations to our study. Our study was not blinded, introducing the risk of bias on the part of the operator. Because it was obviously not possible to have a blinded technique, an attempt was made to reduce bias by having the patient enrolled in the study before randomization and the operator chosen before the insertion technique was known.

**Table 3.** Outcome measures for each group (n=130).

Outcome Measures	Landmark Group, N=65	Ultrasonographic Group, N=65	Difference (US-LM)	95% CI
Successful insertion	51/65 (78.5%)	61/65 (93.9%)	15.4%	3.8%–27.0%
Success on first attempt	36/51 (70.6%)	50/61 (82.0%)	11.4%	–4.4% to 27.2%
Start to flash time, s	132	138	6	–99 to 88
Start to line working time, s	271	281	10	–118 to 98
Complications	11 (16.9%)	3 (4.6%)	–12.3%	–1.9% To –22.8%

**Table 4.** Operator experience and success rates for each technique (n=130).

Measured Variable	Landmark		Ultrasonography	
	Inexperienced	Experienced	Inexperienced	Experienced
Lines, No.	33	32	36	29
Lines per operator, No., median* (IQR)	3.5 (3.0–5.0)	3.5 (2.0–6.5)	4.0 (3.0–5.75)	3.0 (1.25–5.0)
Success rate (95% CI)	24/33 (72.7%) (54.5%–86.7%)	34/36 (84.4%) (67.2%–94.7%)	27/32 (94.4%) (81.3%–99.3%)	27/29 (93.1%) (77.2%–99.2%)

\*Thirteen operators in total, 5 experienced and 8 inexperienced; 3 inexperienced reclassified as experienced during the study period.

Assembly bias may have occurred because our sample was nonconsecutive.

With regard to access times, we attempted to standardize the initial start time by defining it as the time that localization of the vein commenced. The time to set up the ultrasonographic machine and prepare the probe was not included.

Although an experienced operator was arbitrarily defined as having performed more than 25 successful traditional landmark internal jugular vein catheter insertions, this may not truly reflect the experience of the operator. Experience with the Seldinger technique was not used in the definition, and some operators may have been classified as inexperienced despite being experienced with other approaches for central venous catheterization.

Because of consent issues, some critically ill patients could not be enrolled. The benefits of having an internal jugular vein catheter inserted rapidly, on the first attempt and without complications, may be greatest in these ED patients.

## DISCUSSION

There are only a few studies in the literature about ultrasonographically guided central venous access in the ED.<sup>1,16–18</sup> Hudson and Rose<sup>16</sup> described 2 patients in whom ultrasonography was used to establish central access through the internal jugular vein in the ED. Hrics et al<sup>17</sup> evaluated the use and success of ultrasonographically assisted central venous catheterization of the internal jugular vein in the ED setting. There were 40 attempts at internal jugular vein catheters in 34 patients. Ultrasonography was used in 32 of 40 attempts, and incidences of successful puncture and cannulation using ultrasonography were 93.8% (30/32) and 81.3% (26/32) compared with 62.5% (5/8) and 62.5% (5/8) in the landmark group. The study found that single-needle-pass punctures and successful venipunctures were significantly improved with ultrasonographic guidance. However, the authors noted that it

did not identify a decrease in the complication rates, because the incidence of complications was low as a result of the study's small sample size.

Other potential study limitations were that patients were not randomized, and only 8 of 32 attempts with ultrasonography were performed under real-time ultrasonography. Miller et al<sup>1</sup> also compared the ultrasonographic and landmark techniques for central venous access in the ED. Of the 122 patients, the femoral approach was used in 74 patients. For the internal jugular vein approach, 9 were landmark and 28 were ultrasonographically guided. Mean skin to blood flash time was 115 seconds in the ultrasonographic group versus 512 seconds in the landmark group. Fewer central venous access attempts were required in the ultrasonographic group compared with the landmark group, 1.6 versus 3.5. There were 10 complications (14%) in the landmark group and 6 complications (12%) in the ultrasonographically guided group. These results were not specific to internal jugular vein catheter insertion.

Our study comparing ultrasonographic guidance and the landmark technique for internal jugular vein catheterization in an ED had a 93.9% success rate (61/65) in the ultrasonographic group and a 78.5% success rate (51/65) in the landmark group. In the Denys et al<sup>13</sup> prospective study on cardiac catheterization patients, cannulation of the internal jugular vein was achieved in 302 of 302 patients (100%) using ultrasonography and in 266 of 302 patients (88.1%) using the landmark approach. Slama et al<sup>15</sup> in 1997 performed a prospective randomized study in an ICU of a university hospital. Internal jugular vein cannulation was successful in 37 of 37 (100%) patients in the ultrasonographic group and 32 of 42 (76%) in the control group.

A number of studies suggest that an increase in the number of insertion attempts is associated with a higher complication rate. In the McGee and Gould<sup>4</sup> review of central venous catheter complications, the incidence of mechanical

complications after 3 or more insertion attempts was 6 times the rate after 1 attempt. Therefore, the number of attempts to successful venipuncture and catheter placement is important. In our study, cannulation was successful with the first attempt in 50 of 61 (82.0%) patients in the ultrasonographic group and 36 of 51 (70.6%) patients in the landmark group. The mean number of attempts was 1.6 for the landmark group and 1.3 in the ultrasonographic group. Our results are similar to those of other studies performed in critical care settings that demonstrated fewer attempts to successful catheter insertion with ultrasonographic guidance. Mallory et al,<sup>12</sup> in their study of 27 critically ill patients, found that 24.8% of the patients required more than 2 attempts for successful cannulation with the landmark technique compared to 7.3% in the ultrasonographic group. In the Troianos et al<sup>19</sup> study of internal jugular vein cannulation in cardiothoracic surgical patients, 56 of 77 (73%) patients in the ultrasonographic group were cannulated on the first attempt compared to 45 of 83 (54%) patients in the landmark group.

Our overall complication rate was 10.8%, 4.6% for the ultrasonographic group and 16.9% for the landmark group. Hematoma occurred in 3.1% of patients and carotid artery puncture in 1.5% of patients in the ultrasonographic group. In the landmark group, hematoma occurred in 10.8%, carotid artery puncture in 6.2%, and pneumothorax in 1.5% of patients. In the Denys et al<sup>13</sup> study, hematoma occurred in 0.2%, carotid artery puncture in 1.7%, and brachial plexus irritation in 0.4% of patients when ultrasonography was used. In the landmark group, hematoma occurred in 3.3%, carotid artery puncture in 8.3%, and brachial plexus irritation in 1.7% of patients. In the Teichgraber et al<sup>8</sup> study, complications were fewer with ultrasonography: neck hematoma 2% versus 10%; carotid artery puncture 0% versus 12%; plexus irritation 4% versus 6%.

Some studies have suggested that ultrasonographic guidance leads to a faster insertion time. Denys et al<sup>13</sup> found that the mean access time (skin to vein) was 9.8 seconds with ultrasonography and 44.5 seconds by the landmark approach. In the Teichgraber et al<sup>8</sup> study of 100 patients undergoing internal jugular vein catheterization, mean access time was 15.2 seconds with ultrasonography compared to 51.4 seconds with the landmark technique. However, we did not find shorter access times with ultrasonographic guidance. The time to localization of the vein and the clinically important time of successful placement of a catheter were both longer with ultrasonographic guidance compared to the landmark technique. The varying levels of operator experience, the relative new use of the ultrasonographic machine in the ED, and the limited sample size may have been contributing factors to our findings.

In 11 of 12 patients in whom the initial landmark technique failed and crossover occurred, an internal jugular vein catheter was successfully inserted on the same side with the use of ultrasonography. The image offered by ultrasonography allowed

the user to visualize the exact relationship between the carotid artery and the internal jugular vein, determine the depth to the vein, and assess its patency.

In the meta-analysis by Randolph et al,<sup>7</sup> the benefits of ultrasonographic guidance were shown across a number of operators with varying levels of experience in central venous catheterization. Miller et al<sup>1</sup> commented in their study that, regardless of experience, ultrasonographic guidance resulted in absolute decreases in the time to blood flash and the number of central venous access attempts. The inexperienced physicians required more time and an increased number of attempts for both techniques. However, the results were not specific to internal jugular vein insertion, although all lines were inserted in the ED.

In our study, experienced operators had a 4.5% higher success rate and were more successful on the first attempt (85.2% versus 69.0%) than inexperienced operators. Experienced operators had 2 failed catheter insertions under ultrasonographic guidance compared to 5 in the landmark group. Inexperienced operators had 2 failed catheter insertions with ultrasonography compared to 9 in the landmark group. The fastest access times were for experienced operators using the landmark technique. The slowest access times were for inexperienced operators using the landmark technique. Access times were faster with ultrasonographic guidance for inexperienced operators but not for experienced operators.

In summary, we found a significant increase in the success rate and a significant decrease in the complications rate when internal jugular vein catheters were inserted using real-time ultrasonographic guidance compared with the landmark technique in the ED. In EDs with ultrasonography available, ultrasonographically guided insertion of internal jugular vein catheters should become the standard of care.

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