Prospective Evaluation of Central Venous Pressure (CVP) Catheters in a Large City-County Hospital

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Over a 12-month period, this survey was conducted prospectively to examine the complication rate associated with the insertion and use of central venous catheters on the Louisiana State University Surgical Service at Charity Hospital, New Orleans. No attempt was made to alter or influence the current techniques and methods for catheter insertion. Three-hundred and ninety-seven patients received 554 catheters. The overall complication rate was 13.7%. Major mechanical complications occurred with 4.0% of catheters, minor mechanical complications occurred with 4.5% of catheters, and infectious complications occurred with 5.2%. Of the 22 major mechanical complications, 13 were associated with increased morbidity. Twelve of the 13 complications with morbidity occurred with 286 subclavian catheterizations (4.2%), while only 1 of the 13 complications with morbidity occurred with 248 internal jugular catheterizations (0.4%). Based on these data, it is recommended that the internal jugular approach be used in the majority of patients, reserving the subclavian approach for patients on long-term total parenteral nutrition or when the internal jugular approach is not feasible technically.

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FOR YEARS central venous pressure catheters have been used for various purposes including access for total parenteral nutrition, access to the central venous system from monitoring of the central venous pressure, and for rapid administration of fluid or blood products. With the advent of pulmonary artery catheterization and monitoring, access to the central venous system has become a routine necessity in the critical care environment.

Reported complication rates have varied from 0%[14] to 21%[12] with most investigators reporting a 1% to 7% noninfectious mechanical complication rate.[2,4,6,8,9,16] Some complications are fatal.[1] This survey of ongoing experience was conducted with no attempt to alter or influence the current techniques, policies, or methods of catheter insertion. The purpose of this investigation was to evaluate prospectively the current trends and complications, both technical and infectious, after more than a decade of "routine" central venous pressure catheterizations, and to compare this with other studies. Based on these data, recommendations are made for future use.

Material and Methods

Over a 12-month period, all patients with central venous catheters on the Louisiana State University Surgical Service at Charity Hospital, New Orleans, Louisiana were studied for complications of placement and use. No stipulations were made about the training of the person inserting the catheter. No stipulation was made about site of insertion or manner of placement. After each catheter was placed, usually within 24 hours of placement, one investigator personally interviewed the physician placing the catheter and collected patient data.

The patients were visited daily by one investigator, and any complication or change in status was reported. The person placing the catheter was interviewed again as the need arose and after the catheter was removed.

Results

Three hundred and ninety-seven patients received 554 catheters with an average of 1.40 catheters per patient. The majority of the patients were black (72%), and 69% of the patients were male. The mean age of the patients was 46 years (range 8–99). Catheters were placed in patients in the third decade more commonly, followed by patients in the seventh decade, and then by patients in the fourth decade. Of the 397 patients, 236 patients were emergency admissions, and 161 patients were admitted electively (Tables 1 and 2).

Two catheters were placed by cut-down and 552 were placed percutaneously. Sterile techniques were utilized

Prize winning essay of the Surgical Association of Louisiana for the best research performed by a surgical resident, presented in part at the annual meeting of the Surgical Association of Louisiana. November 14, 1981, New Orleans.

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Submitted for publication February 26, 1982.

0003-4932/82/1100/0560 $01.05

for all but five of the 554 catheters. Catheters were placed as an emergency procedure in 39.9% of patients. Volume resuscitation and CVP monitoring were the reasons for placement in 73.6% of the 397 patients (Table 3). The major reason for discontinuation of a catheter was that it was no longer needed (54.3% of catheters (Table 4). The catheter was removed for proved or suspected complications in 9.4% of catheters. Of the 554 catheters placed, 96% were thought to be necessary in retrospect while only 22 were thought to be unnecessary. Five hundred and twenty-five catheters were thought to have accomplished their intended purpose.

The mean length of time a catheter was in place was 97.3 hours with a range from minutes to 43 days. Sixty-two per cent of the catheters were placed for less than three days, 20% were in place for three to seven days, and 18% were continued for greater than seven days.

The level of training of the house staff placing the catheters was varied, but the junior house officer level predominated. (Table 5). The most common site of catheter insertion was by the subclavian route (51.6%). Internal jugular catheters were placed 44.8% of the time, with the remaining catheters placed either in the external jugular vein or in the basilic vein.

Complications

There were 76 complications associated with the 554 catheters. Twenty-nine or 38.2% of the 76 complications occurred in patients who had their catheters placed by first-year surgical residents, 32.9% of complications occurred after catheters were placed by second-year house officers, and 15.8% occurred after catheters were placed by third-year house officers. The remaining 10 or 13.2% occurred after catheters were placed by other house staff. The majority (57.9%) of the complications occurred in patients who had catheters placed by the subclavian route. All cases of pneumothorax, venous thrombosis, loss of catheter into patient, and four of the five cases of hydrothorax occurred in this group of patients. The remainder of the complications were associated with the internal jugular route. Arterial puncture and catheter sepsis were the most common complications with this approach. The external jugular and basilic vein sites were not associated with any complications. There were no deaths attributable to the placement of central venous catheters, and only 5% of the catheters were considered to have caused additional morbidity.

The remainder of the results are subdivided into three major areas: major mechanical complications, minor mechanical complications, and infectious complications.

Major Mechanical Complications

Of the 76 total complications, 22 are considered major for a 4.0% major mechanical complication rate. These include arterial puncture (six patients), hydrothorax (five), venous thrombosis (four), pneumothorax (three), air embolus (three), and loss of catheter into the patient's central venous system (one) (Table 6).

Surgical house officers in their first year of residency training placed 178 catheters with six major technical complications for a complication rate of 3.4%. Second-year surgical house officers had ten major complications in 152 catheter insertions (6.6%). Third-year surgical house officers inserted 63 catheters and had five major technical complications (7.9%). A total of 161 catheters were placed by individuals other than those in the first three years of surgical training. There was only one major technical complication for this composite group (0.6% complication rate). The single additional complication was caused by a house officer one.

All three patients with a pneumothorax had an increase in morbidity, and each required a chest tube. All

TABLE 1. *Diagnosis—Emergency Admission (n = 236)*

Diagnosis	Number of Patients	Percent of Total Patients (n = 397)
Penetrating trauma	147	37.0
Shock	119	30.0
Blunt trauma	49	12.3
GI bleeding	38	9.6
Perforated viscus	32	8.1
Intestinal obstruction	25	6.3
Peritonitis	19	4.8
Other	25	6.3

TABLE 2. *Diagnosis—nonemergency Admission (n = 161)*

Diagnosis	Number of patients	Percent of Total Patients (n = 397)
Major intra-abdominal surgery	50	12.6
Cardiac surgery	29	7.3
Thoracic surgery	16	4.0
GI disease no surgery	27	6.8
Vascular surgery	21	5.3
Other	18	4.5

TABLE 3. *Reason for Placement in 397 Patients with 554 Catheters*

	Percent of Patients
Volume resuscitation	73.6
Monitor CVP	73.6
Hyperalimentation	28.7
Preliminary to Swan–Ganz	25.2
No suitable peripheral vein	9.8
Previous catheter discontinued	8.6
Vasoactive agent or other central medication administration	1.3

TABLE 4. *Reason Catheter Discontinued*

Reason	Percent of Catheters
No longer needed	54.3
Patient death	13.5
Complication occurred	9.4
Became nonfunctional	9.2
Removed inadvertently	8.8
Other	4.7

pneumothoraces were caused by first-year surgical house officers, and all three resulted after attempts with the subclavian approach.

All four patients with venous thromboses had increased morbidity, and all catheters were placed by the subclavian route. The average length of time a catheter was in place in this subgroup was 252 hours which is considerably greater than the average length of time for all catheters of 97 hours. All patients developed significant upper extremity swelling, and two patients had venography documentating the thrombosis.

The six patients who suffered arterial puncture had no increase in morbidity, and all their catheters were placed by the internal jugular approach. The one patient with the catheter embolus to the central venous system had additional morbidity caused by the necessity for catheter retrieval. In the five patients with hydrothorax, four of the catheters were placed by the subclavian route, and one was placed by the internal jugular approach. Three of these patients required tube thoracostomy for drainage.

An air embolus occurred in three patients. Two patients had their catheters placed via the subclavian route and one patient had his catheter placed by the internal jugular route. Two patients had a profound increase in morbidity with seizures and shock, and one of these patients sustained a cardiac arrest. Both patients recovered. The third patient had an unquestionable, audible entry of a large volume of air through the central catheter. Prompt recognition and proper positioning of the patient probably account for the absence of significant morbidity in this patient.

TABLE 5. *Physician Placing Catheter*

	No. of Catheters	% of Catheters
Surgery HO1	178	32.1
Surgery HO2	152	27.4
Surgery HO3	63	11.3
Surgery HO4	10	1.8
Anesthesiologist	79	14.3
Other	72	13.0
Total	554	100%

Overall, 14 of the catheters associated with major technical complications were placed by the subclavian route with the remaining eight being placed by the internal jugular approach. However, when considering the 13 patients who had significant added morbidity because of the complication, 12 of their catheters were placed by the subclavian approach, and only one was placed by the internal jugular approach (Table 7). Analysis of major technical complications by month of insertion revealed no distinct pattern.

Minor Mechanical Complications

There were 25 minor mechanical complications that occurred in 4.5% of all catheters placed. These included improper position (20 catheters), inability to thread the catheter (four), and bleeding from the puncture site (one). There was no increase in morbidity or mortality associated with these complications.

Infectious Complications

Infectious complications included suspected catheter sepsis, documented catheter sepsis, and infection at the skin level. This subgroup accounts for 29 of the 76 complications and occurred in 5.2% of all catheters under investigation. In general, there was very poor documentation for catheter-related sepsis. Of the total 554 catheters, only 29 catheters were documented to have been cultured. Of these, only five were culture positive. Two patients had blood cultures drawn through their catheters, and these were positive. Sixteen patients had positive blood cultures from sources other than the catheter. One hundred and thirty-eight patients (34.8%) had either known or suspected infection elsewhere. Thus, the majority of patients who had their catheters removed for suspected sepsis had no actual proof of infection related to their catheter. It appears that when a patient had a clinical infection of undetermined origin, the central venous catheters were removed because of their potential as the source of that infection.

Discussion

This prospective evaluation of 554 central venous catheters was conducted as a survey of ongoing experience to examine the complication rate associated with the insertion and use of central venous catheters. No attempts were made to alter or influence the current techniques and methods for catheter insertion.

The majority of the 397 patients receiving catheters were black males between the ages of 21 and 30. The

most common admitting diagnoses were penetrating trauma and shock. The most common nontrauma admitting diagnosis was a major intra-abdominal surgical disease. The most common site for central venous access was via the subclavian approach (52%). The most common reasons for placement of these catheters were for volume resuscitation and for CVP monitoring, both thought necessary in 73.6% of the patients. The major reason for discontinuing the catheter was that it was no longer needed for its intended purpose (54% of catheters). With only a few exceptions, the catheters were thought to have accomplished their intended purpose.

There was no correlation between the month of insertion and the number or kind of complications that were detected. It was suspected prospectively that the majority of the complications would occur at the beginning of a residency year (July) because of the inexperience of the new house officers. This trend was not seen.

Infectious complications (either suspected or proved) were the most common subgroup of complications (5.2% of all catheters). Minor mechanical problems, which included improper position, technical problems with the catheter, and bleeding from the puncture site, comprise 4.5% of the total complication rate. By far the most serious complications were those of arterial puncture (six), hydrothorax (five), venous thrombosis (four), pneumothorax (three), air embolus (three), and loss of catheter into the patient (one). The total major mechanical complication rate was 4.0%. The overall complication rate, including major and minor mechanical and infectious, was 13.7%. There were no deaths related to central venous catheter complications.

The majority of complications occurred when house officers in the first two years of surgical training were the persons placing the catheters, but they also were the individuals who placed the largest number of catheters. It also appears that third-year surgical house officers had the highest major mechanical complication rate of 7.9%; however, for the 13 patients who suffered additional morbidity from their complication, only one had his catheter placed by a third-year surgical house officer. The highest resultant morbidity associated with a complication was seen with second-year surgical house officers.

The site of insertion in the 22 patients with major technical complications was divided fairly equally between the internal jugular route and the subclavian route. When patients were examined for whether there was increased morbidity (13 patients), it was found that the subclavian approach was used in 92.3% of these patients. Further analysis reveals that 12 of the 13 complications with morbidity occurred with 286 subclavian catheterizations (4.2%), while only one of the 13 complications with morbidity occurred with 248 internal jugular catheterizations (0.4%).

TABLE 6. *Major Mechanical Complications*

Complication	Number	Location of Catheter		Morbidity
		Subclavian	Int. Jug.	
Arterial puncture	6	0	6	0
Hydrothorax	5	4	1	3
Venous thrombosis	4	4	0	4
Pneumothorax	3	3	0	3
Air embolus	3	2	1	2
Loss of catheter into patient	1	1	0	1

By far the most common complication encountered with the internal jugular route was suspected or known catheter sepsis which may reflect the problems that occur with maintaining a sterile dressing over the catheter when it is in this position. Another complication related to this position is arterial puncture primarily of the carotid artery. All the arterial punctures that occurred in this review were associated with the internal jugular approach, but none produced additional morbidity.

Because of poor documentation, the true catheter sepsis rate could not be proved. It is likely that the actual sepsis rate is lower, because the vast majority of patients included in this category had suspected, but not proved, catheter sepsis. The rate of catheter-related sepsis reported in the literature varies from 4.1%[5] to 39.8%[3] with most reporting a rate around 7%.[10,11]

The complication rates of surgical house officers is higher than that for other house officer groups placing catheters on the general surgical service. Two probable explanations for this are that the surgery house officers placed most of the catheters that were inserted in emergency situations, and the favorite site for insertion by surgery house officers was the subclavian location.

Thus, while the overall complication rate of 13.7% is rather high, the major mechanical complication rate of 4.0% compares favorably with other studies.[2,4,8,9,13,15] Only 13 of 554 catheters resulted in major mechanical complications with added morbidity (2.3%), with no deaths attributable to these complications. These results show that the internal jugular route for central venous

TABLE 7. *Major Mechanical Complications*

Catheterizations with complication	—22 (4.0%) (n = 554)
Catheterizations with morbidity	—13 (2.3%) (n = 554)
Subclavian catheterizations with morbidity	—12 (4.2%) (n = 286)
Internal jugular catheterizations with morbidity	— 1 (0.4%) (n = 248)

access is far safer than the subclavian route when considering complications that produce patient morbidity. Only 0.4% of internal jugular catheterizations resulted in patient morbidity as compared with 4.2% morbidity with the subclavian approach to central venous catheterization. The major difficulties with internal jugular catheterization are with carotid artery puncture and with an increase in septic complications over the subclavian route.

As judged by these data, central venous catheterization is an acceptably safe technique when performed by house officers in training. However, it is not without some morbidity, and therefore should be used selectively as indicated. It is recommended further that the internal jugular approach be used in the vast majority of patients, reserving the subclavian approach for patients on long-term total parenteral nutrition or when the internal jugular approach is technically not possible.

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