Previously we reported the methodology, success rate, and time required to insert single-orificed Sorensen CVP kit catheters in neurosurgical patients via antecubital veins using intravascular electrocardiography (IVECG). Our results using this catheter were less than satisfactory, as the overall success rate was only 76%, and the time required for insertion was 8 ± 5 min (mean ± SD).

Recently a multi-orificed catheter, the Bunegin-Albin CVP Kit (Cook® Incorporated, Bloomington, IN) has become available. Multi-orificed CVP catheters may be preferred over single-orificed CVP catheters because multi-orificed catheters appear superior for treatment of venous air embolism (VAE). The developers of the Cook® multi-orificed catheter have reported their methodology, success rate, and time required to place the catheters via cephalic veins in patients undergoing neurosurgical or general surgical procedures. Their overall success rate was 91% and the mean time required for placement was 4 min. However, since that report, there has been no independent confirmation of their results.

The present study was designed to determine the success rate and time required to place Cook® catheters in neurosurgical patients via antecubital veins using IVECG. In addition, values not reported by the developers of the Cook® catheter were determined: the variability in placement times, the success rates for right and left basilic and cephalic veins, the initial position of the distal portion of the Cook® catheter following the recommended placement instructions, and the relationship between initial position of the distal portion of the catheter and arrhythmias.

**Materials and Methods**

The study was conducted prospectively in 63 patients undergoing major neurosurgical procedures in which CVP monitoring was regarded as contributing to their anesthetic management. The study was approved by the Human Subjects Committee of the University of Washington. All catheters were inserted by anesthesia residents under the guidance of the authors, with patients in the supine position and the arm abducted. In most cases, the first attempt at venipuncture was made using the right basilic vein, if this vein was judged adequate for venipuncture. If not, or if the first venipuncture attempt was unsuccessful, then the right cephalic or the left basilic or cephalic vein was used. In several cases, after considering the position that the patient would be placed in during surgery, it was decided to make the first attempt at venipuncture on the left basilic vein. The procedure was abandoned if more than 20 min passed without successful placement.

The Cook® catheter was inserted according to instructions using the J-wire for the Cook® catheter (3.0 mm radius on the J-curve, 150 cm length, 0.078 cm OD). Either an 18-gauge thin-wall 9.0-cm introducer needle or a 16-gauge 7.5-cm over-the-needle Teflon® catheter was used for venipuncture. The wire was advanced until the silver mark on the wire (located approximately at the midpoint of the wire) was 1.0–2.0 cm outside the hub of the introducer needle or 6.0–7.0 cm outside the hub of the introducer catheter. This placed the distal tip of the wire about 67 cm beyond the venipuncture site. The Cook® catheter (0.195 cm OD, 60 cm in length) was advanced over the wire until the hub of the catheter passed just beyond the silver mark on the J-wire. This placed the distal tip of the catheter about 53 cm beyond the venipuncture site. Under IVECG guidance, the catheter was advanced or withdrawn until the distal portion of the catheter was located just proximal to the junction of the superior vena cava (SVC) and right atrium (RA). Arrhythmias occurring during catheter placement were recorded.

The time for catheter insertion was defined as time from the beginning of the first venipuncture attempt to securing the proximal portion of the catheter. The time for catheter insertion included time for failed venipuncture, wire insertion, etc., and was truncated at 20 min.

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for unsuccessful catheter placements. Venipuncture was considered successful if the introducer catheter or needle could be advanced into the vein and blood freely aspirated from the introducer. Cook® catheter placement was considered successful when IVECG complexes characteristic of the desired location were observed. Postoperatively, venipuncture sites and antecubital veins into which catheters had been inserted were examined for redness, tenderness, swelling, or induration both during patients' in-hospital recovery and at follow-up clinic appointments. Catheters were removed at the discretion of the surgeons, generally on the day following surgery.

The mean times for catheter insertion, success rates, and patients' age and weight were computed for the group as a whole. Reasons for failed catheter insertion were tabulated according to the classifications used in our previous report. The initial location of the distal portion of the catheter was generalized into one of the following areas: right ventricle (RV), RA, inferior vena cava (IVC), SVC, and other. The incidence of arrhythmias was compared between each of these initial locations using the variance ratio test with a $P < 0.05$ considered statistically significant.

### RESULTS

When insertion of an introducer needle or catheter was successful (any antecubital vein), the distal tip of the Cook® multi-orifed catheter was able to be positioned just above the SVC-RA junction in 97% of cases, or 58 of 60 patients. The overall success rate for placement of the Cook® catheter, which includes patients in whom insertion of an introducer was not accomplished, was 92%, or 58 of 63 patients (table 1). In 42 of 63 patients, venipuncture was first attempted on the right basilic vein. In 12 of 63 patients (19%), the right basilic vein was absent or too small to attempt venipuncture. In nine of 63 patients, venipuncture was first attempted on an antecubital vein other than the right basilic. Venipuncture failed in six of the 42 patients in whom venipuncture was first attempted on the right basilic vein, and other antecubital veins were then tried. Overall, an introducer was placed in 60 of 91 attempts (66%).

The number of successful Cook® catheter insertions via each vein is shown in table 1. The success rate for placing the Cook® catheter just above the SVC-RA junction was similar using the right basilic, right cephalic, or left basilic vein. The mean time taken for all (successful and failed) catheter placement attempts was 6.5 ± 3.6 min (mean ± SD). Forty-eight percent of successful placements were completed in 5 min or less, and 97% were completed in 15 min or less.

Using the present insertion technique, the distal portion of the Cook® catheter initially was located in the RA in 24 of 60 patients (40%) (table 2). The tip initially was in the SVC in 21 patients (35%), in the IVC in seven patients, (12%), in the RV in six patients (10%), and in uncertain locations in two patients (3%). Ventricular ectopic beats were observed in seven patients. In five of these seven patients, the catheter tip was initially in the RV. Premature atrial contractions were observed in two patients, and nodal rhythm in one patient. The incidence of ventricular ectopic beats was higher when the distal portion of the catheter was initially located in the RV (83%) than when the distal portion of the catheter was initially located in the RA, IVC, or SVC. The incidence of other arrhythmias was too small for statistical comparison.

Failure to position the tip of the Cook® multi-orifed catheter in the desired location (just above the SVC-RA junction) occurred in five of 63 patients (table 3). The leading cause for failure was inability to insert the introducer catheter or needle into the vein even though

### Table 1. Results of Attempts to Insert Introducers and Cook® Multi-orifed Catheters

<table>
<thead>
<tr>
<th>Vein</th>
<th>Number of Attempts</th>
<th>Inadequate Vein</th>
<th>Failed Introducer Insertion</th>
<th>Successful Introducer Insertion</th>
<th>Successful Insertion of Catheter</th>
</tr>
</thead>
<tbody>
<tr>
<td>R. basilic</td>
<td>54</td>
<td>12</td>
<td>6</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>R. cephalic</td>
<td>13</td>
<td>0</td>
<td>3</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>L. basilic</td>
<td>17</td>
<td>1</td>
<td>5</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>L. cephalic</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Totals</td>
<td>91</td>
<td>15</td>
<td>16</td>
<td>60</td>
<td>58</td>
</tr>
</tbody>
</table>

### Table 2. Initial Location of Catheter Tip and Arrhythmias

<table>
<thead>
<tr>
<th>Initial Location of Catheter Tip</th>
<th>Ventricular Ectopic Beats</th>
<th>Premature Atrial Contractions</th>
<th>Nodal Rhythm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right atrium</td>
<td>24</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Superior vena cava</td>
<td>21</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Inferior vena cava</td>
<td>7</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Right ventricle</td>
<td>6*</td>
<td>5*</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>60</td>
<td>7</td>
<td>2</td>
</tr>
</tbody>
</table>

* Incidence of ventricular ectopic beats significantly greater when catheter tip initially located in right ventricle than when catheter tip initially located in right atrium, superior vena cava, inferior vena cava, or other, $P < 0.05$. 

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venipuncture was attempted at multiple antecubital sites (three patients, 5%). In no cases were all veins judged inadequate to attempt venipuncture. The other cause for failure to place the Cook® catheter was inability to find the desired P-wave complex (two patients, 3%). In one case, excessive interference on the IVECG made it unusable and the position of the catheter tip could not be determined. In the other case, an IVECG with small negative P wave was the only complex obtained, despite repeated attempts to reposition the catheter. A chest X-ray was obtained and the catheter tip was found to be in the internal jugular vein. In all cases where an introducer needle or catheter was inserted, the Cook® catheter wire was advanced through the introducer to the desired depth and the Cook® catheter was advanced over the wire.

There was no intraoperative morbidity associated with the procedure other than small hematomas at some of the venipuncture sites. No patients developed thrombophlebitis in the vein through which the Cook® catheter was inserted. Patient characteristics were mean age of 50 ± 15 yr (range of 23 to 72 yr) and mean weight of 70 ± 15 kg (range of 45–100 kg).

DISCUSSION

The overall success rate (92%) and mean time to insert (6.3 ± 3.6 min) Cook® catheters in this study was similar to the success rate (91%) and time for insertion (4 min—variability not given) previously reported by the developers of the catheter.4 This success rate is similar to results reported by Holt,6 Jamai et al.,7 Cucchiara et al.,8 and Bridges et al.9 with single-orificed catheters placed via antecubital veins (88–98%), and is superior to the less than satisfactory success rates reported by us1 and by others10-18 with single-orificed catheters placed via antecubital veins (59–82%). The range of insertion times in this study (48% within 5 min, 97% within 15 min) approximates the satisfactory results reported by Cucchiara et al. with single-orificed catheters (54% within 5 min, 94% within 15 min).8

In this study, the leading cause for failed catheter insertion was failed introducer insertion (3/63 patients). The developers of this catheter reported the same leading cause for failed catheter insertion (4/77 patients).4 The incidence of this cause for failure was less with the Cook® catheter, where a 16-gauge catheter or 18-gauge needle serves as the introducer, than in our previous study with the Sorensen catheter (8/80 patients), where a 13-gauge catheter serves as the introducer.1

<table>
<thead>
<tr>
<th>Reason</th>
<th>Number of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>After successful introducer insertion</td>
<td>0</td>
</tr>
<tr>
<td>Unable to thread wire through introducer</td>
<td>0</td>
</tr>
<tr>
<td>Unable to thread catheter over wire</td>
<td>2</td>
</tr>
<tr>
<td>P-wave changes not seen</td>
<td></td>
</tr>
<tr>
<td>Because of failed introducer insertion</td>
<td>3</td>
</tr>
<tr>
<td>Attempted but failed (on all attempts)</td>
<td></td>
</tr>
<tr>
<td>Not attempted as all veins adequate for</td>
<td>0</td>
</tr>
<tr>
<td>venipuncture</td>
<td></td>
</tr>
</tbody>
</table>

In this study, the second leading cause for failed catheter placement was failure to observe the desired P wave complex (2/63 patients). The developers of this catheter reported a similar incidence of failure to observe the desired P-wave complex (3/77 patients).4 The incidence of this cause for failure was less with the Cook® catheter, where a J-wire serves as a guide for the catheter, than in our previous study with the Sorensen catheter (7/80 patients), where no wire guide is used.1

In this study, the incidence of arrhythmias (10/60 patients, 17%) was greater than that reported by the developers of this catheter (3/70 patients, 4%).4 In the present study, the highest incidence of arrhythmias occurred when the catheter tip was initially located in the right ventricle (5/6 patients). This finding suggests that the incidence of arrhythmias might be reduced by avoidance of right ventricular catheterization. The technique used here was to advance the J-wire until the silver mark on the wire was 1.0–2.0 cm outside the hub of the introducer needle or 6.0–7.0 cm outside the hub of the introducer catheter. This method placed the distal tip of the catheter about 5 cm beyond the venipuncture site. This technique appears to be satisfactory for J-wire insertions via left antecubital veins because no right ventricular catheterizations occurred. However, six right ventricular catheterizations occurred when right antecubital veins were used.

Thus, to prevent right ventricular catheterization and associated arrhythmias, it may be preferable to insert the distal tip of the wire and multi-orificed catheter only 45–49 cm beyond the venipuncture site when right antecubital veins are used. The distal portion of the wire will be at 45–49 cm beyond the venipuncture site by using the technique described here but advancing the J-wire only until the silver mark is 19.0–23.0 cm outside the hub of the introducer needle or 24.0–28.0 cm outside the hub of the introducer catheter. The distal portion of the multi-orificed catheter will be at 45–49 cm beyond the venipuncture site if the multi-orificed catheter is then advanced over the wire until the hub of the catheter is 14.0 cm beyond the silver mark on the J-wire. Other measures that may minimize the

incidence of right ventricular catheterization and associated arrhythmias are assessing the location of the J-wire and/or catheter by IVECG and utilizing a pressure transducer to monitor catheter pressure immediately upon removal of the J-wire. The occurrence of arrhythmias during catheter insertion emphasizes the need for continuous ECG monitoring during catheter insertion.

REFERENCES


Anesthesiology

Bronchospasm after Cardiopulmonary Bypass in a Heart-lung Transplant Recipient

EUGENIE S. CASELLA, M.D.,* LINDA S. HUMPHREY, M.D.*

The development of severe bronchospasm, which delays separation from cardiopulmonary bypass (CPB), has been previously reported in patients undergoing coronary artery bypass grafting.1−5 These patients responded to conventional treatment for bronchospasm and subsequently did well. We report a case of severe bronchospasm in the denervated lung of a heart-lung transplant recipient, which not only made separation from CPB extremely difficult, but remained a serious clinical problem for the remainder of the patient’s hospitalization.

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Key words: Complications: bronchospasm. Lung: asthma. Surgery: heart-lung transplantation.

CASE REPORT

A 22-yr-old man with primary pulmonary hypertension was admitted to the coronary care unit in anticipation of heart-lung transplantation. He had developed progressive dyspnea, chest pain, and dependent edema over the previous 18 months, leading to near total exercise intolerance. Even at rest, he required continuous supplemental oxygen and a 75° semi-erect position. He had a long-standing history of exercise-induced asthma (diagnosed by spirometry), which was poorly controlled because of gastric intolerance to the anti-asthmatic medications. Family history was positive for asthma. He was a non-smoker. His weight had been stable around 90 kg. He had undergone general anesthesia for appendectomy 4 yr ago without problems. He denied an allergic history. His current medications were nifedipine 20 mg every 8 h, digoxin 0.125 mg per day, and furosemide 80 mg per day.

At the time of the preoperative physical examination, the patient was dyspneic sitting upright in bed. He was afibrile, arterial blood pressure 138/80 mmHg, heart rate 90 bpm, and respiratory rate 22 breaths/min. There was no cyanosis and trace pedal edema. Breath sounds were clear but distant. Cardiac examination revealed a 2/6 systolic murmur at the left lower sternal border on inspiration, normal S1, loud P2, no S3, and no right ventricular heave. There were occasional ectopic beats. Chest radiograph showed cardiomegaly with enlargement of the right ventricle and both pulmonary arteries. Electrocardiogram showed right ventricular hypertrophy with a strain pattern

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