Complications of central venous catheters: Internal jugular versus subclavian access—A systematic review

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Objective: To test whether complications happen more often with the internal jugular or the subclavian central venous approach.

Data Source: Systematic search (MEDLINE, Cochrane Library, EMBASE, bibliographies) up to June 30, 2000, with no language restriction.

Study Selection: Reports on prospective comparisons of internal jugular vs. subclavian catheter insertion, with dichotomous data on complications.

Data Extraction: No valid randomized trials were found. Seventeen prospective comparative trials with data on 2,085 jugular and 2,428 subclavian catheters were analyzed. Meta-analyses were performed with relative risk (RR) and 95% confidence interval (CI), using fixed and random effects models.

Data Synthesis: In six trials (2,010 catheters), there were significantly more arterial punctures with jugular catheters compared with subclavian (3.0% vs. 0.5%, RR 4.70 [95% CI, 2.05–10.77]). In six trials (1,299 catheters), there were significantly less malpositions with the jugular access (5.3% vs. 9.3%, RR 0.66 [0.44–0.99]). In three trials (707 catheters), the incidence of bloodstream infection was 8.6% with the jugular access and 4.0% with the subclavian access (RR 2.24 [0.62–8.09]). In ten trials (3,420 catheters), the incidence of hemato- or pneumothorax was 1.3% vs. 1.5% (RR 0.76 [0.43–1.33]). In four trials (899), the incidence of vessel occlusion was 0% vs. 1.2% (RR 0.29 [0.07–1.33]).

Conclusions: There are more arterial punctures but less catheter malpositions with the internal jugular compared with the subclavian access. There is no evidence of any difference in the incidence of hemato- or pneumothorax and vessel occlusion. Data on bloodstream infection are scarce. These data are from non-randomized studies; selection bias cannot be ruled out. In terms of risk, the data most likely represent a best case scenario. For rational decision-making, randomized trials are needed.

Central venous catheters (CVCs) are essential for the clinical management of many patients. Indications for a CVC are the intravenous administration of specific drugs (e.g., catecholamines), parenteral nutrition, hemodialysis, and hemodynamic monitoring. In many institutions, patients undergoing major surgery and patients with critical illness or cancer routinely receive a CVC. Thus, percutaneous placement of a catheter into a central vein is a frequent procedure in many clinical settings. At the Geneva University Hospitals, 35,087 patients were hospitalized in 1998, and 2,848 CVCs were used in that year. If we assume that none of the patients received more than one CVC, then 8.1% of all hospitalized patients had a CVC.

The most frequently used anatomical sites for CVC insertion are the internal jugular and the subclavian vein (1). However, in an individual patient, criteria for choosing one approach over the other often remain unclear. This choice could depend on the complication rate with each approach. Indeed, there is a substantial risk of mechanical lesions (e.g., arterial puncture, pneumothorax, cardiac tamponade, or nerve lesions) and thrombotic or septic complications with each CVC. These complications are related to the procedure of the insertion or to the catheter itself. An improved understanding of CVC-related risks might help clinicians to choose one approach over the other in specific clinical settings. The aim of this quantitative systematic review was to gather the best available evidence on the risks related to internal jugular and subclavian central venous catheterization, to critically appraise and synthesize the data, and to quantify the different risks.

METHODS

Search Strategy. An extensive search of the relevant literature without restriction to the English language was carried out using MEDLINE (PubMed and KnowledgeFinder 4.19), EMBASE, and the Cochrane Library. The date of the last electronic search was June 30, 2000. Key words used for the final search were “central venous catheter,” “catheterization,” “catheterisation,” “subclavian,” “jugular,” “complication,” “infection,” “thrombosis,” “success rate,” “stenosis,” “pneumothorax,” “hematothorax,” “clinical trial,” and “prospective.” Reference lists of retrieved reports and relevant review articles (2–5) were also checked. We did not contact manufacturers. Authors were contacted if there was ambiguity about original data.

Inclusion and Exclusion Criteria, End Points, and Data Extraction. Relevant studies had to be full reports of comparisons of internal jugular vs. subclavian central venous catheterization, in adults or children, reporting dichotomous data on any complications that were possibly related to the CVC (insertion or catheter related), and published in a peer-reviewed journal. The type of CVC (e.g., dialysis) had no influence on these inclusion criteria. Data from abstracts, letters, review articles, animal studies, and postmortem studies were not considered. Studies on tunneled catheters, implantable devices, radiologically assisted catheter insertion, or catheter placement by cut-down technique were not ana-
lyzed. Abstracts of all potentially relevant reports were screened by two authors (SR and BW). Papers that did not clearly meet the inclusion criteria were excluded at this stage. From included studies, dichotomous data on complications per insertion site were extracted as reported by the original authors. Data on patients, clinical settings, and operators were extracted from each included study. Data abstraction was carried out by one investigator (SR) and cross-checked by the two others.

**Validity Assessment.** There was an intention to include data from randomized trials only. However, our search strategies did not retrieve one single randomized trial that was relevant for the purpose of our study (i.e., in which patients were randomly allocated to one of the two CVC accesses). In clinical studies that are not properly randomized, there is a risk of selection bias; selection bias may lead to overestimation of the effect of a treatment (6). Another frequent problem with nonrandomized studies is unequal group sizes. This may happen when trialists have a free choice of what intervention to use, and when for external reasons (e.g., institutional policies) one intervention is systematically used more often compared with another. Undue weight would then be given to the intervention that is used more often. We assume that the magnitude of inequality between group sizes in a comparative but nonrandomized trial to some extent reflects the degree of selection bias in that trial. Thus, to minimize the risk of selection bias, we excluded trials from further analyses when their group sizes differed more than twofold. Finally, we excluded trials with retrospective data collection, inasmuch as those are prone to observational bias and because data selection cannot be ruled out.

**Meta-analyses.** Dichotomous data on complications per number of inserted CVCs were analyzed. We calculated relative risks (RR) with 95% confidence intervals (CI) (RevMan version 4.0, Cochrane Library, Oxford, UK). We used the fixed-effect model when the data were homogeneous (p > .1) and, otherwise, a random effects model. As an estimate of the clinical relevance of any difference between the two CVC accesses, we calculated the number-needed-to-treat (7). The number-needed-to-treat indicated how many catheters had to be inserted by one route for one catheter to lead to a complication that would not have happened had the other approach been chosen. A positive number-needed-to-treat indicated that the end point happened more often with the jugular approach. A negative number-needed-to-treat indicated the opposite.

**RESULTS**

**Retrieved Reports.** We screened 747 reports (Fig. 1). Of the 35 potentially relevant trials, 4 were excluded because data on complications were lacking (8–11), and 7 because the insertion site was unequal (12–18). Seven trials were excluded because the number of analyzed jugular and subclavian catheters was highly unequal (i.e., ratio >2); ratios were 2.6 (19), 2.8 (20), 3.0 (21), 3.1 (22), 3.9 (23), 4.9 (24), and 8.1 (25). We contacted authors of seven original studies for further information; none replied to our enquiry.

We eventually analyzed 17 prospective, comparative, nonrandomized reports, published between 1982 and 1999, with data on 2,085 jugular and 2,428 subclavian catheters (Table 1). There were no differences in the incidence of hemato- or pneumothorax (1.3% vs. 1.3%, RR 0.76 [0.43–1.33]) (Fig. 5). Catheters varied from single to quadruple-lumen, and were most often made of polyurethane or polyethylene. Most patients were from surgical or medical intensive care units. Catheters were inserted by house officers, residents, or fellows. In three reports, no such information was available (32, 38, 39).

In some trials, additional central vein accesses (e.g., femoral) were tested; these data were not analyzed.

**Arterial Puncture.** Arterial puncture (six trials, 2,010 catheters) (27–29, 31, 36, 41) was significantly more often reported with the jugular approach compared with the subclavian approach (3.0% vs. 0.5%, RR 4.70 [95% CI, 2.05–10.77]) (Fig. 2). The number-needed-to-treat was 39 (95% CI, 27–73).

**Catheter Malposition.** Catheter malposition (six trials, 1,299 catheters) (29, 31, 33, 34, 36, 41) was significantly less often reported with the jugular access (5.3% vs. 9.3%, RR 0.66 [95% CI, 0.44–0.99]) (Fig. 3). The number-needed-to-treat was 25 (95% CI, 15 to 42).

**Bloodstream Infection.** Three trials (707 catheters) (32, 38, 40) reported on bloodstream infection. The incidence was 8.6% with the jugular access and 4.0% with the subclavian access. The data were heterogeneous; the RR (random effects model) was 2.24 (95% CI, 0.62–8.09) (Fig. 4).

**Hemato- and Pneumothorax.** In ten trials (3,420 catheters) (26–29, 31–33, 35, 36, 41), there was no difference in the incidence of hematoma or pneumothorax (1.3% vs. 1.5%, RR 0.76 [0.43–1.33]) (Fig. 5).

**Vessel Occlusion.** Four trials (899 catheters) (28, 31, 33, 40) reported on vessel stenosis or thrombosis. There was no significant difference in the incidence of vessel occlusion (0% vs. 1.2%, RR 0.29 [0.07–1.33]) (Fig. 6).

Further reported complications were insertion site infection and local hematoma. These were reported in no more than two trials each; no sensible conclusions could be drawn.

**DISCUSSION**

In many institutions, the anatomical site of CVC insertion is chosen on the grounds of personal experience or local policies rather than on evidence-based guidelines. The aim of this quantitative systematic review was to clarify some of the controversies that exist on the relative risk of internal jugular compared...
with subclavian access. If there was evidence for an increased risk of specific complications with one approach, then clinicians may take advantage of that knowledge for insertion of a CVC in an individual patient.

The main methodological problem was that there were no relevant randomized trials. There is empirical evidence that data from studies that lack proper randomization may overestimate the effect of a treatment (6). Observational data on treatment efficacy do not necessarily need to be different from randomized data (43). Also, our analysis is about harm and not about efficacy, and there is evidence from systematic review that observational studies may underestimate the

Table 1. Analyzed trials

<table>
<thead>
<tr>
<th>Reference</th>
<th>Analyzed Catheters</th>
<th>Catheter Type</th>
<th>Setting</th>
<th>Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrera 1996 (26)</td>
<td>52</td>
<td>CVC, 3-lumen (7-Fr), introducer sheaths (8-Fr)</td>
<td>ICU and ward</td>
<td>ICU fellows</td>
</tr>
<tr>
<td>Bo-Linn 1982 (27)</td>
<td>201</td>
<td>CVC</td>
<td>10% cardiopulmonary arrest; 59% emergencies (catheterization within 1 hr); 31% elective (catheterization within 1 day)</td>
<td>Medical house officers in training</td>
</tr>
<tr>
<td>Eisenhauer 1982 (28)</td>
<td>248</td>
<td>CVC</td>
<td>Surgical service (volume resuscitation, CVP monitoring), 39.9% as an emergency procedure</td>
<td>Surgical house officers in training</td>
</tr>
<tr>
<td>Fisher 1999 (29)</td>
<td>306</td>
<td>CVC, 3-lumen (7-Fr) or 4-lumen (8-Fr), PAC (8.5-Fr), dialysis catheter (12-Fr)</td>
<td>Gastroenterology unit, patients with liver disease (INR 1.5 or greater, platelet count 150 or less ×109/L)</td>
<td>Attending clinician</td>
</tr>
<tr>
<td>Gil 1989 (30)</td>
<td>118</td>
<td>CVC, 1-lumen (polyurethane) and 3-lumen (polyvinylchlorid)</td>
<td>Medical ICU</td>
<td>Treating physician</td>
</tr>
<tr>
<td>Kaiser 1981 (31)</td>
<td>52</td>
<td>CVC</td>
<td>Oncology</td>
<td>Main author</td>
</tr>
<tr>
<td>Lehr 1988 (32)</td>
<td>290</td>
<td>CVC</td>
<td>Abdominal surgery</td>
<td>Unknown</td>
</tr>
<tr>
<td>Luyt 1996 (33)</td>
<td>56</td>
<td>CVC, 1-, 2-, and 3-lumen</td>
<td>Multidisciplinary ICU</td>
<td>Residents</td>
</tr>
<tr>
<td>McGee 1996 (34)</td>
<td>65</td>
<td>CVC, 16 cm and 20 cm</td>
<td>Community teaching hospital</td>
<td>Surgical, medical, or anesthesiology residents</td>
</tr>
<tr>
<td>Miller 1999 (35)</td>
<td>230</td>
<td>PAC (7.5-Fr, polyvinylchlorid), CVC (7-Fr, polyurethane)</td>
<td>Surgical and medical ICU and general medical ward</td>
<td>Residents or 4th-year medical students</td>
</tr>
<tr>
<td>Peres 1990 (36)</td>
<td>58</td>
<td>CVC, 3-lumen</td>
<td>Operating room and ICU</td>
<td>Anesthesiologist</td>
</tr>
<tr>
<td>Pinilla 1983 (37)</td>
<td>50</td>
<td>CVC (14 G and 17 G), PAC, 4-lumen G188(Fr)</td>
<td>Surgical ICU and operating room</td>
<td>Residents</td>
</tr>
<tr>
<td>Poisson 1991 (38)</td>
<td>76</td>
<td>CVC (polyurethane and polyethylene)</td>
<td>ICU</td>
<td>Unknown</td>
</tr>
<tr>
<td>Richet 1990 (39)</td>
<td>114</td>
<td>CVC</td>
<td>ICU</td>
<td>Unknown</td>
</tr>
<tr>
<td>Schillinger 1994 (40)</td>
<td>50</td>
<td>Dialysis catheter</td>
<td>Hemodialysis</td>
<td>Nephrology medical staff</td>
</tr>
<tr>
<td>Sessler 1987 (41)</td>
<td>101</td>
<td>CVC, 1-lumen (16 G) or 3-lumen (7-Fr), Side port introducer (8.5-Fr), PAC</td>
<td>ICU and medical center</td>
<td>House officers in training</td>
</tr>
<tr>
<td>Singh 1982 (42)</td>
<td>18</td>
<td>PAC</td>
<td>Critical care center, operating room and emergency room</td>
<td>ICU fellows or residents</td>
</tr>
</tbody>
</table>

Jug, jugular; Subcl, subclavian; CVC, central venous catheter; Fr, French; ICU, intensive care unit; PAC, pulmonary artery catheter; G, gauge.

Study | Jugular n/N | Subclavian n/N | RR (95% CI Fixed) | Weight % | RR (95% CI Fixed) |
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bo-Linn</td>
<td>14/201</td>
<td>0/173</td>
<td>9.0 [5.5, 13.6]</td>
<td>25.84</td>
<td>25.84 [15.6, 31.6]</td>
</tr>
<tr>
<td>Eisenhauer</td>
<td>6/246</td>
<td>0/286</td>
<td>7.0 [4.5, 11.6]</td>
<td>12.1</td>
<td>12.1 [8.2, 16.1]</td>
</tr>
<tr>
<td>Fisher</td>
<td>0/306</td>
<td>1/352</td>
<td>21.1 [15.6, 29.6]</td>
<td>43.3</td>
<td>43.3 [36.9, 50.7]</td>
</tr>
<tr>
<td>Kaiser</td>
<td>3/49</td>
<td>0/51</td>
<td>7.4 [4.5, 12.4]</td>
<td>15.6</td>
<td>15.6 [10.1, 22.3]</td>
</tr>
<tr>
<td>Peres</td>
<td>3/58</td>
<td>2/107</td>
<td>21.2 [15.6, 29.0]</td>
<td>43.3</td>
<td>43.3 [36.9, 50.7]</td>
</tr>
<tr>
<td>Sessler</td>
<td>3/101</td>
<td>2/72</td>
<td>35.3 [27.0, 45.5]</td>
<td>80.4</td>
<td>80.4 [72.8, 88.1]</td>
</tr>
</tbody>
</table>

Total (95% CI): 29/963 (5/1047) 100.0 [2.05, 10.77] 100.0 [2.05, 10.77]

Chi-square 7.54 (df=4); P: 0.18 Z=3.66 P: 0.000001

Figure 2. Relative risk (RR) of arterial puncture with jugular vs. subclavian access. n, number with arterial puncture; N, number of catheters; 95% CI Fixed, 95% confidence interval, fixed effect model.
harm of a treatment compared with randomized controlled trials (44). Another issue is related to the operators in these studies. For instance, to use exclusively one CVC approach in an institution may reduce the CVC-related risk inasmuch as all operators would then accumulate experience and improve dexterity. Finally, there may have been the possibility of underreporting of CVC-related complications in studies where these complications were secondary end points. This may explain, at least in part, some of the observed variability in event rates in these trials. However, there was no evidence that this potential underreporting would have favored one approach compared with the other. Consequently, these data are likely to represent a best case scenario in terms of risk assessment for both CVC accesses.
One of the most frequently reported complications of CVC insertion is arterial puncture (45). Based on these systematically searched data, of 39 attempts to access the internal jugular vein, 1 will lead to an arterial puncture that would not have been the case had the subclavian approach been chosen. We do not know if this significantly increased risk with the jugular access was the result of an underreporting of arterial punctures with the subclavian approach inasmuch as puncture of a carotid artery is usually easier to detect than puncture of a subclavian artery. Although the puncture of a carotid artery seems to happen more often, effective hemostasis is much easier (manual compression). Also, Doppler ultrasound guidance is an effective method in decreasing the incidence of this complication (46). It is unlikely that clinicians will abandon the internal jugular access based on these risk data.

The data on catheter malpositioning may have more impact on clinical decision-making. Malpositioning has been reported in 14% of CVCs even when they were inserted by experienced clinicians (47). In the analyzed trials, malpositioning happened significantly less often with the internal jugular access. Of 25 CVCs inserted via the internal jugular vein, one will not be malpositioned that would have been the case had the subclavian route been chosen. Also, malposition of a subclavian catheter may include entry into the opposite subclavian vein or the neck veins, whereas many jugular catheters may simply be pulled back if the tip lies in the right atrium. This is yet another argument in favor of the jugular approach. The jugular access should be chosen if a fast and correct catheter tip placement is mandatory (e.g., hemodynamic monitoring in a patient in shock). Malpositioning of a CVC per se, independent of the access may lead to serious complications. The positioning of catheter tips within the cardiac silhouette is associated with an increased risk of cardiac tamponade (48). Also, positioning of a catheter tip in a subclavian vein is associated with a high risk of thrombus formation and vessel occlusion (49). In cancer patients, for instance, rates of catheter-related thrombi of >50% have been reported (50). When a CVC is leading to a thrombosis, the risk of catheter-related sepsis may be increased (19). In this meta-analysis, only four trials reported on vessel occlusion (vessel stenosis or thrombosis), and there was no evidence of any difference between the two CVC approaches.

Catheter-related bloodstream infection remains an important cause of nosocomial infection. In patients with a CVC, the risk of acquiring a bloodstream infection was reported to range between 1% and 10% (51). The economic burden of bloodstream infection is considerable; it may prolong the hospital stay and increase mortality in critically ill patients (52). Mortality of catheter-related bloodstream infection increases with older age, longer length of hospital stay, cancer, disease of the digestive tract, and Candida species detection (53). Data on bloodstream infection could be analyzed from three trials (707 catheters) only. Bloodstream infection happened more often with jugular catheters. The absolute risk reduction compared with the subclavian access was almost 5%; this would translate into a number-needed-to-treat of about 20. This potentially clinically relevant result was, however, not statistical significant (i.e., the 95% CI of RR included 1).

There was no evidence of any difference in the incidence of hemato- and pneumothorax. Patients at increased risk of pulmonary complications (e.g., patients with chronic obstructive pulmonary disease or acute respiratory distress syndrome) have not been included in these studies.

CONCLUSIONS

These data from nonrandomized clinical trials are likely to reflect a best case scenario in terms of risk assessment. There is some evidence that there are more arterial punctures but less catheter malpositions with the internal jugular compared with the subclavian access. There is no evidence of any difference in the incidence of hemato- or pneumothorax and vessel occlusion. bloodstream infection happened more often with the internal jugular access, but the data were heterogeneous and there was no evidence of statistical significance. The lack of randomized comparisons of jugular and sub-

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**Figure 6.** Relative risk (RR) of vessel occlusion with jugular vs. subclavian access. n, number with vessel occlusion; N, number of catheters; 95% CI Fixed, 95% confidence interval, fixed effect model.

<table>
<thead>
<tr>
<th>Study</th>
<th>Jugular n/N</th>
<th>Subclavian n/N</th>
<th>RR (95% CI Fixed)</th>
<th>Weight %</th>
<th>RR (95% CI Fixed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eisenhauer</td>
<td>0/248</td>
<td>4/206</td>
<td></td>
<td>55.7</td>
<td>0.13[0.01,2.37]</td>
</tr>
<tr>
<td>Kaiser</td>
<td>0/52</td>
<td>0/63</td>
<td></td>
<td>6.0</td>
<td>1.21[0.02,59.64]</td>
</tr>
<tr>
<td>Lux</td>
<td>0/56</td>
<td>0/84</td>
<td></td>
<td>5.0</td>
<td>1.67[0.09,22.85]</td>
</tr>
<tr>
<td>Schillinger</td>
<td>0/50</td>
<td>2/55</td>
<td></td>
<td>33.3</td>
<td>0.20[0.01,4.06]</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>0/406</td>
<td>8/493</td>
<td></td>
<td>100.0</td>
<td>0.26[0.07,1.33]</td>
</tr>
</tbody>
</table>

Chi-square 1.04 (df=3); P = 0.58; Z = -1.59; P = 0.10

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clavian catheters is highly unsatisfactory. Randomized comparisons are needed to verify these findings. In the meantime, clinical decision-making will have to be based on the best available evidence.

ACKNOWLEDGMENTS

We thank Daniel Haake from the Documentation Service of the Swiss Academy of Medical Sciences for his help in searching electronic databases.

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come of nosocomial bloodstream infec-
tions: A 6-year validated, population-

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