

Comparison of Catheter-related Infection and Tip Colonization between Internal Jugular and Subclavian Central Venous Catheters in Surgical Neonates

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Background: The primary aim of this study was to compare catheter-associated infections and tip contaminations between percutaneously placed central venous catheters in the internal jugular and subclavian veins in surgical neonates undergoing major noncardiac surgery.

Methods: The prospectively computerized protocols of 295 procedures were analyzed retrospectively.

Results: One hundred twenty-nine internal jugular venous (group I) and 107 subclavian venous catheters (group S) were included. The median postconceptual age was 37 weeks in group I and 38 in group S. The weight ranged from 580 g to 4.5 kg in group I and from 820 g to 4.5 kg in group S at the time of insertion. Significantly more catheter-associated infections were observed in group I (15.5 vs. 4.7%; chi-square analysis: $P < 0.01$). The internal jugular venous catheters were also associated with a significantly increased probability of an earlier onset of a catheter-associated infection compared with the subclavian venous catheters (log rank test: $P < 0.01$; Cox model: $P < 0.01$). This probability was only slightly increased by a lower weight (Cox model: $P = 0.075$), and it was not increased by a lower age (Cox model: $P = 0.93$). Significantly more catheter tips were contaminated by pathogens in group I (55.8 vs. 33.6%; chi-square analysis: $P < 0.01$).

Conclusion: The internal jugular venous catheters were associated with a higher infection rate as well as earlier onset of catheter-associated infection compared with the subclavian venous catheters.

CENTRAL venous catheters (CVCs) are often mandatory devices when caring for critically ill newborn and premature infants. However, any foreign object that is introduced into the body is at risk for infection. CVCs carry a particularly high risk for infection.¹ Several studies in adults have shown that percutaneous placement of a CVC in the internal jugular vein has been associated with a higher risk of catheter-associated infection (CAI) compared with the subclavian vein.²⁻⁴ The main aim of this study was to compare the rates of CAI as well as tip colonization of percutaneously placed CVCs between the internal jugular and subclavian veins in newborn and

premature infants while undergoing major noncardiac surgery.

Materials and Methods

Study Population

This study was conducted from 1998 to 2006 at the General Hospital of Klagenfurt, Klagenfurt, Austria. After approval by the local ethics committee, the computerized protocols of 295 procedures of central venous lines placement were reviewed. It included the neonates who received a CVC placed percutaneously in either the internal jugular or the subclavian vein while undergoing major abdominal or thoracic noncardiac surgery. Study inclusion criteria only comprised babies who underwent major surgery during their first 28 days of life or, if born prematurely, until 28 days had elapsed from the calculated birth date. Furthermore, only babies weighing less than 4.6 kg at the time of the operation were included. Availability of the tip culture after CVC removal was another prerequisite for study inclusion. If percutaneous catheter implantation was unsuccessful, the patient was excluded from the study. Each case of catheterization was individually evaluated.

Protocol for Catheter Care

All CVCs were inserted in the operating room during general anesthesia before surgery. The insertion was performed by three anesthesiologists experienced in central venous line placement in infants. The vein selected for cannulation was determined by the attending anesthesiologist. Medical reasons only had an influence on the right or left side being chosen. Aseptic technique was used during all insertions. This included the use of sterile gloves, drapes, gowns, and facemasks. Before insertion, the patient's skin was disinfected by rubbing the site of insertion with sterile gauze soaked in a solution of 2% chlorhexidine in 70% isopropyl alcohol and was allowed to dry. The patients were put into the Trendelenburg position, except for infants weighing less than 1 kg, who remained supine. A small towel was placed under the shoulders. Using the Seldinger technique while applying light pressure on the liver, the vein was punctured with a 22-gauge needle (Seldiflex; Plastimed, Saint-Leu-La-Forêt, France), a 24-gauge needle (Arrow; Arrow International, Inc., Reading, PA), or a 19-gauge butterfly needle (Epicutaneo-Cava-Katheter; Vygon, Aachen, Germany). As the entry site, the lower

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approach to the internal jugular vein and the infraclavicular approach to the subclavian vein were chosen.⁵

After successful venous puncture and introduction of the appropriate guide wire, a 2-French single-lumen catheter (Seldiflex) was threaded over the guide wire into the vein. If the weight of the baby exceeded 1.9 kg, either a 2-French single-lumen Seldiflex catheter or a 4-French double-lumen catheter (Arrow) was inserted, depending on the decision of the anesthetist. In one baby weighing 580 g, a 27-gauge Silastic catheter (Epicutaneo-Cava-Katheter; Vygon, Aachen, Germany) was advanced through a butterfly needle into the internal jugular vein. In another baby also weighing only 590 g, a 24-gauge Abbocath (Abbott Ireland Pharmaceutical Operations, Sligo, Ireland) was inserted.

During the last year of the study period, ultrasound (iLook 25; SonoSite Limited, Hitchin, United Kingdom) was used to locate the vein and to confirm its patency before the cannulation. However, the puncture of the vein was never performed under ultrasound vision.

The Seldiflex and Arrow catheters were then fixed by stitches. No subcutaneous tunnelling was performed. The exit site of the CVC was covered by an occlusive transparent dressing (Tegaderm; Smith & Nephew Medical Limited, Hull, England) unless the baby's weight was less than 1 kg. In this case, Steri-strips (3M Health Care, Neuss, Germany) were used because of the vulnerable skin in this age group. Proper catheter tip positioning in the superior caval vein was confirmed by x-ray. Antibiotics were administered preoperatively if necessitated by the underlying surgical disease or early onset infection after birth.

Postoperatively all babies were cared for in the neonatal intensive care unit (NICU) or intermediate care unit for neonates. Both units were managed by the same team of doctors and nurses who had all been trained in neonatal intensive care medicine. Any manipulations on the catheters were performed by the NICU nurses following a standardized protocol. Three-way stopcocks connecting the hub with the intravenous sets were changed every 48 h, or even 24 h when used for total parenteral nutrition administration. The stopcocks and hubs were disinfected with a solution of 2% chlorhexidine in 70% isopropyl alcohol using a sterile swab immediately before and after each manipulation and wrapped in sterile gauze dressing. Babies weighing less than 1 kg received a low dose of vancomycin prophylactically until the CVC was in place.

The CVCs were removed as soon as they were no longer needed or if any complication occurred. The diagnosis of a CAI was made in patients who developed signs of infection (fever [$< 38^{\circ}\text{C}$], hypothermia [$< 36.5^{\circ}\text{C}$], leukocytosis or leukopenia, apnea, or bradycardia) with no other clinically apparent site of infection.⁶ If the tip culture was found to be negative after catheter removal, the diagnosis was reversed to suspected cath-

eter infection retrospectively. In addition to immediate catheter removal, these neonates were treated with antibiotics.

Microbiologic Procedures

The catheter tips were taken under sterile conditions to the microbiology laboratory where they were plated on a 5% horse blood agar plate. The inoculum was spread with a loop over the plate. Later, a liquid bouillon medium was added. Plates were incubated at 37°C for 48 h and kept at room temperature for a further 2–3 days. Cultures were considered positive when at least two of the four inoculated quadrants revealed bacterial or fungal growth. Isolates were identified by standard methods to species level, and their antibiotic susceptibility was determined.

Data Collection

The following data were recorded by a computerized program (Windows Access; Microsoft Corporation, Redmond, WA) at the time of CVC insertion: date and site of insertion (internal jugular or subclavian vein); physician's name; complications during insertion; material of CVC; antibiotic treatment at the time of insertion; patient's weight and postconceptual age, *i.e.*, weeks = gestational + postnatal age; demographics of the operation. The following data were recorded while the central vascular catheter was in place: antibiotic treatment; duration of catheterization, *i.e.*, number of days that the CVC was in place; reasons for catheter removal; complications (obstruction, dislocation, thrombosis, CAI); culture of the catheter tip after removal and nature of the pathogen.

Statistical Methods

The significance of results was measured by *P* values. *P* values less than 0.05 were deemed as statistically significant. The correlations between the variables (body weight – duration of catheterization, body weight – postconceptual age) were characterized by Spearman rank correlation coefficient (*r_s*). Two-sided significance testing was used for correlations.

The Kolmogorov-Smirnov test was used to test the normal distribution of the data within the groups. To compare different groups of patients, the following tests were used: chi-square analysis for contingency tables, the Fisher exact test for 2×2 tables, and the Wilcoxon-Mann-Whitney test (U test) for ordered data. The log rank test was used to compare the samples of censored data (right censored time intervals), and the Cox proportional hazard model was used to determine the significance of parameters influencing censored data.

For proportions, 95% confidence intervals (CIs) were reported. All calculations were made in SPSS (SPSS Inc., Chicago, IL) and HP-RPL (Reversed Polish Lisp; Hewlett Packard, Corvallis, OR).

Table 1. Relation of Body Weight to Postconceptual Age and Duration of Catheterization

| | Min | Median | Max |
|-----------------------------------|------|--------|-----|
| Group I (n = 129) | | | |
| Body weight, kg | 0.58 | 2.2 | 4.5 |
| Postconceptual age, weeks | 26 | 37 | 44* |
| Duration of catheterization, days | 3 | 10 | 68† |
| Group S (n = 107) | | | |
| Body weight, kg | 0.8 | 2.8 | 4.5 |
| Postconceptual age, weeks | 26 | 38 | 44‡ |
| Duration of catheterization, days | 2 | 10 | 62§ |

Correlation with weight: * Spearman rank correlation coefficient (r_s) = 0.695, significant; † r_s = -0.306, significant; ‡ r_s = 0.599, significant; § r_s = -0.398, significant.

Results

Study Population

We assessed 295 episodes of central venous catheterization. Seven procedures had to be excluded because percutaneous central venous line placement was unsuccessful, and 52 had to be excluded because the culture of the catheter tip after removal was not available, mainly because of the transfer of these infants back to a peripheral neonatal unit after surgery. Whether the catheter tips were cultured there was not known. The 7 unsuccessful procedures included 5 of 167 (2.99%; 95% CI, 0.97–6.85) internal jugular and 2 of 128 (1.56%; 95% CI, 0.19–5.53) subclavian venous cannulations. This difference between the groups was not significant (Fisher exact test: $P = 0.35$).

Two hundred thirty-six procedures were enrolled in this study. These included 129 internal jugular venous catheters (group I) among 103 neonates and 107 subclavian venous catheters (group S) among 84 neonates. The parameters weight, postconceptual age, postnatal age, and duration of catheterization were not normally distributed within the groups (Kolmogorov-Smirnov test: $P < 0.05$).

The weight of the infants at the time of insertion ranged from 580 g to 4.5 kg in group I and from 820 g to 4.5 kg in group S. The median weight in group I was lower by 0.6 kg than in group S (0.6/2.8 = 21.4%). This difference associated with a span of 3.92 kg in group I and 3.7 kg in group S resulted in a significantly lower weight in group I babies compared with group S (U test: $P < 0.01$; table 1). Fifteen neonates in group I and seven in group S weighed less than 1 kg at the time of CVC insertion.

The postconceptual age of the neonates varied from 26 to 44 weeks in both groups. However, the ages were significantly lower in group I compared with group S (median: 37 weeks in group I, 38 weeks in group S), which was in part caused by the large number of patients (U test: $P < 0.01$). There was a significant positive correlation between body weight and postconceptual age in both groups (table 1). The postnatal age at the

time of the CVC insertion did not differ significantly between the groups (median: 1.2 weeks in group I, 2 weeks in group S; U test: $P = 0.18$).

The demographic data of the operations also showed no significant difference between the two groups (chi-square analysis: $P = 0.63$). The majority of operations consisted of laparotomies in both groups.

Characteristics of Catheterization

During the cannulation of the internal jugular vein, two pneumothoraces and one hemothorax (1.8%; 95% CI, 0.37–5.16) necessitating pleural drainage occurred. In two of these babies, successful cannulation of the vein turned out to be impossible. One pneumothorax (0.78%; 95% CI, 0.02–4.28) was reported upon cannulating the subclavian vein, without any further sequelae. Implantation of a CVC was also unsuccessful in this baby. Statistically the serious complications at insertion did not differ between the groups (Fisher exact test: $P = 0.42$). No fatal outcome related either to the insertion procedure or to the CVC *in situ* was noted in any case. In the case of transfer of the patient to a different neonatal unit after surgery, this information became known through personal communication.

In those who were enrolled in the study, the total number of days of catheterization was 1,639 days in group I and 1,360 days in group S. CVCs remained in place for median 10 days in both groups. The difference between the groups was not significant (U test: $P = 0.42$; table 1). There was a significant negative correlation between body weight and duration of catheterization in both groups, *i.e.*, the higher the body weight was, the lower the duration of catheterization was (table 1).

At the time of catheter insertion, 86.2% of patients in group I and 87.1% in group S were on antibiotic treatment for early onset infection after birth or the underlying surgical disease. The most frequently used antibiotics were ampicillin plus netilmicin, and as mentioned previously, in babies weighing less than 1 kg, vancomycin was added as well postoperatively.

Thirty-seven internal jugular venous catheters (28.7%) had to be removed prematurely because of complications, compared with 12 subclavian venous lines (15.2%), which was significant (chi-square analysis: $P < 0.01$). Catheter-related infections and suspected infections accounted for the most common cause of catheter removal in both groups. The second most common reason was an obstruction of the CVC by kinking, which was observed eight times more frequently in the internal jugular venous group (table 2). Clinical thrombosis necessitating catheter removal and catheter dislocation was not different between the two groups (table 2).

By far, most CVCs in both groups were taken out because they were not needed anymore.

Table 2. Complications Leading to Premature Central Venous Catheter Removal

| | Group I (n = 129) | | Group S (n = 107) | |
|----------------------|----------------------|-------------|----------------------|--------------|
| | n (%) | 95% CI | n (%) | 95% CI |
| Infection | 20 (15.5) | 0.09–0.23 | 5 (4.7) | 0.01–0.11* |
| Suspected infection | 7 (5.4) | 0.02–0.12 | 4 (3.7) | 0.01–0.1† |
| Clinical thrombosis | 1 (0.7) | 0.002–0.04 | 2 (1.8) | 0.002–0.06‡ |
| Catheter obstruction | 8 (6.2) | 0.027–0.12 | 1 (0.9) | 0.0002–0.05§ |
| Catheter dislocation | 1 (0.7) | 0.0002–0.04 | — | — |

* Chi-square analysis: $P < 0.01$. † Fisher exact test: $P = 0.38$. ‡ Fisher exact test: $P = 0.43$. § Fisher exact test: $P < 0.05$. || Fisher exact test: $P = 0.54$.

CI = confidence interval.

Catheter-associated Infection

Four times more CAIs were recorded in group I compared with group S, which was significant and resulted in an observed risk ratio of 3.29 (table 2). Summing up catheter-related infections plus suspected catheter-related infections also resulted in a significantly higher rate in group I of 27 (20.9%; 95% CI, 0.14–0.29) versus 9 (8.4%; 95% CI, 0.03–0.15) in group S (chi-square analysis: $P < 0.01$). No significant difference could be detected when comparing the suspected CAIs (table 2).

In babies weighing less than 1 kg at the time of the catheter insertion, more CAIs were found in group I (38.5 vs. 14.3%). This difference was not statistically significant (Fisher exact test: $P = 0.28$). With three times more patients, this result would have reached statistical significance (Fisher exact test: $P = 0.046$).

The Kaplan-Meier plot showed a steady decline of percentage of patients without catheter-related infection with the increasing duration of catheterization (fig. 1). This decline was significantly more rapid in group I compared with group S.

To determine the influence of weight, postconceptual age, and insertion site (internal vs. subclavian vein) on the duration of catheterization until a CAI was observed, we used the Cox model (table 3). Only the choice of the internal jugular vein was associated with a significantly increased probability of a CAI in the course of time, resulting in a theoretical risk ratio of 4.26 according to the Cox model. This probability was only slightly increased in babies with a lower body weight, and it was not increased in babies with a lower postconceptual age.

Catheter Tip Contamination

The results of the catheter tip cultures are displayed in table 4. Nearly twice as many catheter tips were contaminated by pathogens in group I compared with group S, which was significant. Coagulase-negative staphylococci

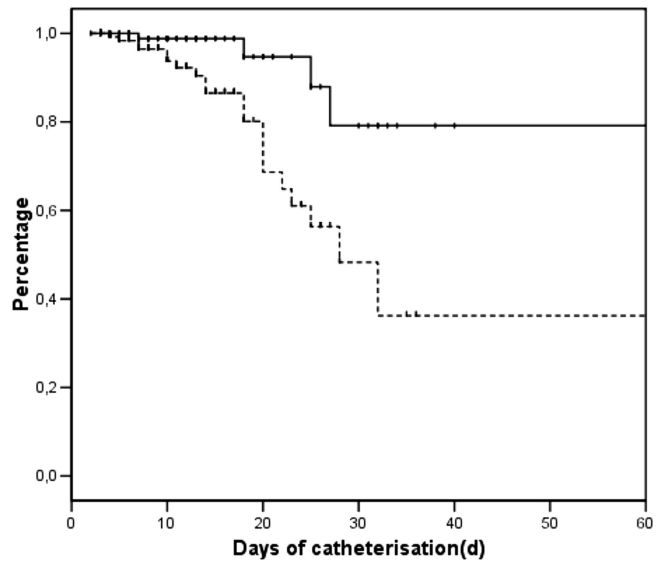


Fig. 1. Kaplan-Meier plot: Proportion of patients without catheter-related infection after days of catheterization. Group I (dashed line), n = 129; group S (solid line), n = 107. The difference is significant ($P < 0.01$, log rank test).

were responsible for 97% of all pathogens. Significantly more catheter tips were contaminated in group I in babies weighing less than 1 kg (84.6 vs. 14.3%; Fisher exact test: $P < 0.01$).

Table 3. Influence of Weight, Postconceptual Age, and Insertion Site (Internal Jugular vs. Subclavian Vein = Treatment Group) on CAIs in the Course of Time (Cox Proportional Hazard Model)

| Model: | $\lambda(t/z) = \lambda_0(t) \cdot \exp(\beta'z)$ | | |
|--------------------|---|---------|---------|
| β : | $\beta = (b_1, b_2, b_3)$, where b_1, b_2, b_3 are the factors of the variables weight, age, and treatment group | | |
| z : | Individual patient parameters | | |
| $\lambda_0(t)$: | Baseline hazard function | | |
| Results | b | var (b) | P Value |
| Weight | 0.483 | 0.112 | 0.075* |
| Postconceptual age | -0.089 | 0.003 | 0.931† |
| Treatment group | 1.454 | 0.265 | 0.002‡ |

* Weakly significant. † Not significant. ‡ Significant.
CAI = catheter-associated infection.

Table 4. Comparison of Catheter Tip Colonization

| | Group I (n = 129) | Group S (n = 107) |
|--|----------------------|----------------------|
| Sterile | 57 (44.2) | 71 (66.4) |
| <i>Staphylococcus coagulase negative</i> | 69 (53.4) | 35 (32.7) |
| <i>Pseudomonas</i> | 2 (1.6) | — |
| <i>Candida</i> | 1 (0.8) | — |
| Multiresistant | — | 1 (0.9) |

Data are presented as n (%).

Sterile vs. nonsterile, chi-square analysis: $P < 0.01$. Sterile vs. *Staphylococcus coagulase negative* vs. rest (summarized), chi-square analysis: $P < 0.01$.

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Discussion

Because of the increased viability of extremely low-birth-weight infants, the number of CVCs required by these babies has increased over the past decades.^{7,8} Basically, all babies born below the 34th gestational week need a central venous line, mainly for parenteral nutrition because of their ileus of prematurity.⁹ Neonatologists usually insert 27-gauge Silastic catheters *via* peripheral veins. Because of their small internal caliber, these lines are unsuitable for blood withdrawal, measurement of central venous pressure, and rapid administration of massive amounts of fluid, which is a major disadvantage if these infants have to undergo major surgery. Two-French Seldiflex catheters usually offer these options for a period of up to 3–4 weeks. However, these lines must be inserted *via* a deep, central vein. This procedure has the risk for potentially life-threatening complications.^{10,11}

In the long term, catheter-related bloodstream infections represent the most common complication of these lines. In an NICU, the relative risk of sepsis is four times higher in a neonate with a CVC compared with a neonate without a CVC.^{12,13} The confirmation of catheter-related sepsis is difficult in neonates. It is often impossible to obtain paired quantitative cultures of blood from a peripheral vein and through the central venous line. Most of the babies in our study were on antibiotic treatment, which could have suppressed the growth of any pathogen in the blood culture anyway. That is why we chose to rely mainly on clinical signs of sepsis with the CVC being the most likely cause. Because no one died of this complication after starting treatment for a CAI, we can exclude having missed any such catheter-associated sepsis. On the other hand, we do not dismiss the possibility that we might have incorrectly diagnosed a suspected CAI that was not present. To our knowledge, no study had been reported that compared the rate of catheter-related infections and contaminations of the catheter tip between internal jugular and subclavian venous lines in neonates and premature infants.

In this investigation, the internal jugular venous lines were associated with a three-times-higher infection rate and a more than two-times-higher infection plus clinically suspected infection rate. The reasons for the higher infection rate of internal jugular venous lines in adults are speculative. We assumed that the easier and therefore maybe slightly better care of the more accessible subclavian venous lines as well as fewer skin folds at the infraclavicular subclavian exit site resulting in a lower colonization rate might have contributed to the better outcome in favor of the subclavian lines. Mahieu *et al.*⁶ regarded the colonization of the exit site as an important risk factor for catheter-associated bloodstream infections. Unfortunately, this investigation, which could

have confirmed our suspicion, was not conducted in our patients.

The CAI risk increases with the duration of time the catheters are in place, with the duration of parenteral nutrition, in extremely small babies weighing less than 1 kg, in catheter hub and exit site colonization, and in surgical neonates.^{6,14} As opposed to adults, the central venous lines in small neonates are usually left in place as long as possible because of the drawbacks of reinsertion. Our study only included neonates undergoing major surgery. A massive toxemia always occurs during invasive surgery, making these babies more vulnerable to infections. The operations performed in our study were similar in both groups, making these patients comparable in our opinion. Altogether, the number of CAIs of both internal jugular (20 of 129; 16.3%) and subclavian venous lines (5 of 107; 4.6%) was rather small compared with another report involving only surgical neonates.¹⁴

Because of the retrospective nature of this survey, we were only able to look at the influence of weight, age, insertion site, and duration of catheterization on the occurrence of a CAI. We could detect neither an earlier onset nor a higher rate of CAIs in younger babies, and the lower weight also had only a minor impact. On the other hand, the risk of a CAI increased with the duration of time the CVC was in place. After 60 days of catheterization, only one patient in each group was still under observation and showed no signs of CAI at the time of the catheter removal. Not surprisingly, the risk of an earlier onset of a CAI was significantly greater with CVCs placed in the internal jugular vein, as shown by the log rank test and Cox model.

The CAIs were also more common in the internal jugular venous group in very small babies weighing less than 1 kg. However, 66 babies would have been needed to render this result statistically significant.

The virtually nonexistent association of low weight and young age with the occurrence of a CAI might even offset the difference in age and weight between the two groups. One possible explanation for the missing clear association of CAIs with low weight and young age could be the fact that all of these tiny babies received vancomycin prophylactically as soon as the CVC was *in situ*. Therefore, the outbreak of a catheter-associated sepsis caused by coagulase-negative staphylococci might have been prevented. Coagulase-negative staphylococci were nearly exclusively responsible for all CAIs as confirmed retrospectively by the pathogens found on the catheter tips (table 4).

In any case of a catheter-related infection or suspected infection, the central venous line was removed immediately. In addition, antibiotic treatment with vancomycin was initiated empirically and the clinical condition always improved quickly, except in one child. In this infant, the catheter-related sepsis was part of a severe *Candida* sepsis originating from the gastrointestinal

tract. The clinical outcome eventually also turned out to be good after the administration of an antimycotic.

The contamination rate of the catheter tips was almost twice as high in the internal jugular venous group compared with the subclavian group (55.8 *vs.* 33.6%). Because of this significant result, no power analysis was performed. This result was even more significant in the very small babies weighing less than 1 kg (84.6 *vs.* 14.3%).

Altogether, 72.6% of the babies with an internal jugular venous catheter and 86.1% of those with a subclavian venous line showed no signs of a CAI at the time of catheter removal.

We used two different types of CVCs, a 2-French single-lumen catheter and a 4-French double-lumen catheter. Although sometimes questioned, there is no proof that multilumen catheters are associated with a higher infection rate.¹⁵ That is why this was not part of our investigation.

The materials of the Seldiflex, Abbocath, Arrow, and Silastic catheters, which were used exclusively during our investigation, consist of polyurethane and silicone. Both materials have been associated with a lower risk of adhesion by microorganisms than polyethylene and polyvinyl chloride. No difference has been shown between polyurethane and silicone.¹⁶ Therefore, we regarded the CVCs as comparable from this point of view.

In one baby of group I and two babies of group S, a venous thrombosis, most likely related to the CVC, was suspected. Clinical symptoms consisted of a massive local swelling. CVCs were removed in both cases without further investigation, and clinical symptoms disappeared soon after that. None of these three patients showed any clinical signs of a CAI.

The small caliber of the catheters used in infants makes them soft and pliable. Therefore, these catheters are prone to obstruction by kinking. Not surprisingly, this problem was observed much more frequently in lines placed in the internal jugular vein when these babies moved their head (6.2% in group I *vs.* 0.96% in group S). This would be another factor exposing the internal jugular vein as the more problematic choice. Sometimes this problem could be solved by changing the dressing; however, this did not turn out to be a long-term solution. Catheter obstruction by kinking was never observed in deeply sedated babies in either group.

In fact, it was the request of the NICU nurses who regarded caring for the subclavian venous catheters as much more convenient that led us to change our policy and target the subclavian vein as the primary choice for a central venous access during the last 2 yr of the study period.

From the insertion point of view, there are pros and cons for both veins. Comparing central venous catheterization sites in infants, Han *et al.*¹⁷ found that the rate of successful catheter placement was highest for the left

subclavian vein. However, complications were significantly more frequent during subclavian vein catheterization.¹⁷ In our study, unsuccessful cannulations and serious complications at insertion seemed to be low and similar in both groups. Unfortunately, the numbers of attempts and inadvertent arterial punctures were not well documented.

Whether the size of the vein should play a role in the choice remains questionable. Although often quoted, no definitive proof exists that the internal jugular vein of infants is larger than the subclavian one.¹⁸ The use of ultrasound is more helpful for the cannulation of the internal jugular vein.¹⁹ Its successful use has even been described in a baby as small as 850 g.²⁰ On the other hand, positioning for the subclavian vein cannulation is much less demanding above all in tiny babies (fig. 2). At the beginning of this study, our intention was to collect as much data as possible about CVCs to obtain a good quality control. That is why we started our computerized program. Nevertheless, it is unlikely that the CAI and contamination rates would be different if we had designed this study prospectively aiming at the comparison of these rates between the internal jugular and subclavian venous catheters. It might even be unethical to design such a prospective study, which would include many babies in a life-threatening situation undergoing emergency surgery.

The smaller the baby is, the more challenging the insertion of a CVC is.²¹ Interestingly, virtually no data exist pertaining to subclavian and internal jugular venous catheters in babies weighing less than 1 kg. Nevertheless, it would be especially this group of patients who would probably benefit most from these lines. It is difficult to obtain large-bore peripheral venous access in these babies so that such a central venous line, which can remain in place over a period of weeks, would represent a major advantage. Intraoperatively, it could even sometimes determine the outcome in terms of survival of the infant if massive fluid shifts or hemorrhages occurred.²² However, the necessity for such a CVC is virtually unpredictable preoperatively.

Furthermore, blood samples can be withdrawn from a 2-French Seldiflex catheter for up to 3 weeks after insertion. Theoretically, this could be associated with a better neurologic outcome of the infant by reducing stress and pain caused by necessary vessel punctures.²³⁻²⁵

Umbilical venous and arterial catheters offer these options as well. However, they are associated with a high number of complications and are therefore usually removed after 6 days.^{13,26} In addition, they must be taken out if a laparotomy of the upper abdomen is performed. Using peripheral arterial lines for obtaining blood is widespread. Unfortunately, these lines are also accompanied by major complications in very small infants and should be left in place for only a couple of days.²⁷ Of course, the number of CVCs in infants weighing less



Fig. 2. Position of an 820-g baby for the cannulation of the subclavian vein.

than 1 kg in this article is by far too small to draw any such positive conclusions from a statistical point of view. We have to admit that one of our tiny babies also only received a 27-gauge Silastic catheter with no option to withdraw blood or administer massive amounts of fluid rapidly.

In conclusion, our study noted a significant difference in terms of CAI, catheter tip colonization, and catheter obstruction in favor of the subclavian venous lines. Whatever CVC catheter is inserted, sterile guidelines upon insertion as well as for the care of the catheter must be followed strictly to minimize the risk of CAI. The apparently low association of CAI and the subclavian venous lines led us to choose this vein as the primary target in neonates over time. Obstruction by kinking was also of only minor concern when the infraclavicular approach to the subclavian vein had been used. NICU nurses seem to prefer this line because of its more convenient management. In the meantime, we believe that it is technically easier to insert this line compared with an internal jugular venous catheter. This may be in contrast to widespread opinion.

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