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ORIGINAL ARTICLE

Internal jugular vein deformities after central venous catheterisation in neonates: Evaluation by Doppler ultrasound

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Aim: The use of a central venous catheter (CVC) through the internal jugular vein (IJV) in neonates is associated with various complications. We postulated that the risk of vein deformity after removing the CVC is underestimated. This study aimed to evaluate, using Doppler ultrasound, morphological changes in the IJV that had undergone CVC insertion during the neonatal period.

Methods: The study consisted of 23 cases, in which 2.7 Fr Broviac (Bard Access Systems, Salt Lake City, Utah, USA) CVCs were inserted through the IJVs of newborns over a 2-year period. After the removal of the CVCs, the IJVs were examined by Doppler ultrasound.

Results: Seventeen cases had normal appearances, but six (26%) cases had deformities. One case had a completely obstructed IJV, and five had abnormal compressibility, echogenic intravascular masses or monophasic waveforms of blood flow. On follow-up, IJV deformities were not improved but tended to be aggravated. There were significant differences in gestational age (36.6 ± 3.2 weeks vs. 30.0 ± 3.9 weeks, $P = 0.002$), body weight at time of CVC insertion (2.60 ± 0.72 kg vs. 1.32 ± 0.47 kg, $P = 0.001$) and duration of catheter use (25.9 ± 13.6 days vs. 49.0 ± 22.0 days, $P = 0.016$) between the normal and deformity groups, respectively.

Conclusions: IJV deformities after central venous catheterisation in neonates are common. A lower gestational age, a lower body weight, and more catheter indwelling days are significant factors affecting the incidence of IJV deformities.

Key words: central venous catheterisation; Doppler ultrasound; internal jugular vein deformities; neonate.

The use of the long-term central venous catheter (CVC) has increased and has become an important part of the treatment of newborn patients.[1,2] However, the insertion of a CVC in neonates is difficult compared with that in older children and adults, and requires a more precise technique and careful attention to avoid catheter-related complications. Although peripherally introduced CVC or percutaneous insertion are the preferred methods,[3] surgical insertion of a subcutaneously tunnelled, cuffed, CVC-like Broviac catheter (Bard Access Systems, Salt Lake City, Utah, USA) through the internal jugular vein (IJV) is a popular method, especially for low-birth-weight neonates because other veins are too small or too difficult to access.[4,5]

Key Points

1. IJV deformities after central venous catheterisation in neonates are common.
2. A lower gestational age, a lower body weight and more catheter indwelling days are significant factors affecting the incidence of IJV deformities.
3. Sequential Doppler ultrasounds are necessary to evaluate catheter-related IJV deformities.

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Central venous catheterisations through the IJV are associated with various complications related to the insertion, use and removal of the catheter, which include infection, sepsis, thrombosis, leakage and dislodgement.[6–8] Deformities of the vein after the removal of the CVC are other possible complications in neonates as a result of injury of the small and fragile IJV, during CVC insertion, and indwelling. However, very little data are available in the literature on this issue.[5] To our knowledge, there are no previous reports of early identification of IJV deformities after CVC removal in neonates and sequential follow-up evaluation. Thus, using Doppler ultrasound, we evaluated the morphology of IJVs, which had undergone catheterisation in the neonatal period with short-term follow-up and sequential follow-up of the deformity group.

Patients and Methods

Between January 2004 and April 2006, 42 newborn patients who were admitted to the neonatal intensive care unit at Severance Children's Hospital underwent insertion of 2.7 Fr Broviac catheters through the IJV. Of these patients, 19 were excluded from the study because they were not evaluated by Doppler ultrasound. Twenty-three patients who had been assessed by Doppler ultrasonographic evaluation of IJV after CVC removal were included in the study, and the clinical data were retrospectively reviewed by the authors. This study was approved by the Institutional Review Board at our hospital. Patient diagnoses are listed in Table 1.

Table 1 Diagnoses of the enrolled neonates

Diagnosis	No. of patients
Oesophageal atresia	1
Duodenal atresa	4
Jejunoileal atresia	6
Malrotation of midgut	2
Small bowel perforation	1
Segmental dilatation of ileum	1
Meconium peritonitis	1
Meconium plug syndrome	1
Duplication cyst of ileum	1
CDH	2
Perinatal asphyxia	1
Bronchopulmonary dysplasia	2

CDH, congenital diaphragmatic hernia.

Single-lumen 2.7 Fr Broviac catheters were inserted by using the following standard technique.[9–11] Through a transverse neck incision, the IJV was isolated between vascular slings. The exit wound was made lateral and superior to the ipsilateral nipple. The catheter was subcutaneously tunnelled from the exit wound to the neck wound and inserted into the vein via a 23-gauge needle puncture, avoiding the use of a purse-string suture. All Broviac catheters were inserted by the same paediatric surgeon (J-TO).

After the catheter was removed, Doppler ultrasonographic evaluations were performed with a mean follow-up period of 2.6 ± 1.4 months (range: 20 days to 4.7 months). We referred to previous published criteria for the diagnosis of IJV deformity.[5,11–13] Compressibility or respiratory variation, visualisation of echogenic intravascular mass and blood flow waveforms were the diagnostic criteria used. All data were compared with the data from contralateral normal IJVs. Patients who had IJV deformities underwent sequential Doppler ultrasonography with long-term follow-up. All sonographic studies were performed by the same radiologist (MJK) using a Philips ATL HDI 5000 unit (Philips, Bothell, WA, USA) with 5–12 linear and 5–8 curved transducers.

Data were reported as mean ± standard deviation and statistically analysed by using SPSS 11.5 (SPSS Inc., Chicago, IL, USA). Differences in gestational age, age at insertion, body weight at insertion, catheter indwelling days and follow-up period between the groups were compared by using a Mann–Whitney *U*-test. A *P*-value of <0.05 was considered significant.

Results

Demographics (Table 2)

The mean gestational age of the patients was 34.8 ± 4.4 weeks (range: 26.1–39.1 weeks) and the mean age at CVC insertion was 7.9 ± 8.3 days (range: 1–28 days). The mean body weight at CVC insertion was 2.27 ± 0.87 kg (range: 0.84–3.89 kg). The smallest patient was 0.84 kg, and six were less than 1.5 kg.

As shown in Table 1, underlying diseases included 20 cases of surgical disease and three cases of medical disease. The CVCs in the surgical cases were inserted in the operating room under general anaesthesia. Three medical cases underwent CVC in the Neonatal Intensive Care Unit (NICU) under sedation and local anaesthesia. All CVCs were inserted through the right IJV, apart from one patient, where it was inserted through the left IJV.

The mean duration of catheter use was 31.9 ± 18.6 days (range: 12–82 days). There were no catheter-related complications during insertion, use or removal.

Doppler ultrasound

Seventeen cases had a morphologically normal appearance. Among these, 12 cases had normal biphasic blood flow pattern; five cases could not be evaluated by Doppler study because of lack of patient cooperation.

Six (26%) of the 23 patients had abnormal IJV morphologies: one patient had complete obstruction of the IJV, and five had abnormal compressibility and respiratory variation of the IJV compared with the contralateral IJV (Fig. 1). Two of these five cases had echogenic intravascular masses on the vein wall, which was diagnosed as thrombosis (Fig. 2). Three cases also had abnormal monophasic blood flow waveforms (Fig. 3).

Five of six cases in the deformity group underwent sequential follow-up by using Doppler ultrasound, with a mean follow-up period of 3.31 ± 0.62 years (range: 2.55–3.86 years) from the first ultrasound evaluation. Three of these cases had complete obstructions of the IJV; two had abnormal compressibility and respiratory variations of the IJV. No patients had clinical manifestations related to IJV deformities.

The deformity group cases are summarised in Table 3.

Comparing the two groups (Table 2)

There were significant differences in gestational age (36.6 ± 3.2 vs. 30.0 ± 3.9 weeks, $P = 0.002$), body weight at catheter insertion (2.60 ± 0.72 vs. 1.32 ± 0.47 kg, $P = 0.001$) and duration of catheter use (25.9 ± 13.6 vs. 49.0 ± 22.0 days, $P = 0.016$) between the normal and deformity groups, respectively. Age at CVC insertion and follow-up period were not significantly different between the two groups.

Discussion

Since the introduction of the Broviac catheter as a CVC option, its use in neonates has become important in providing parenteral nutrition, antibiotics, blood sampling and fluid infusion. Although most Broviac catheters cause no problems, the risk of complications always exists. The literature includes numerous reports of Broviac catheter-related complications during insertion, use and removal.[3–6,14–16] However, after the removal of the catheter, the risk of complications continues to exist and is probably underestimated.

In our study, the overall incidence of deformity was 26%. The rate of incidence was significantly correlated with lower gestational age and lower body weight. There are several possible explanations on why premature and low-birth-weight neonates are more susceptible to deformities. These neonates usually

Table 2 Demographics and results of catheter insertion

	All patients	Normal	Deformity	*P*
No. of patients	23	17	6	
Age at insertion (day)	7.9 ± 8.3	8.2 ± 8.5	8.3 ± 8.8	0.759
Gestational age (week)	34.8 ± 4.4	36.6 ± 3.2	30.0 ± 3.9	0.002
Body weight at insertion (kg)	2.27 ± 0.87	2.60 ± 0.72	1.32 ± 0.47	0.001
Duration of catheter use (day)	31.9 ± 18.6	25.9 ± 13.6	49.0 ± 22.0	0.016
Insertion place				
OR	20	14	6	
NICU	3	3	0	
Follow-up period (month)	2.6 ± 1.4	2.7 ± 1.4	2.2 ± 1.4	0.392

All continuous data are expressed as mean ± standard deviation. NICU, Neonatal Intensive Care Unit; OR, operating room odds ratio.

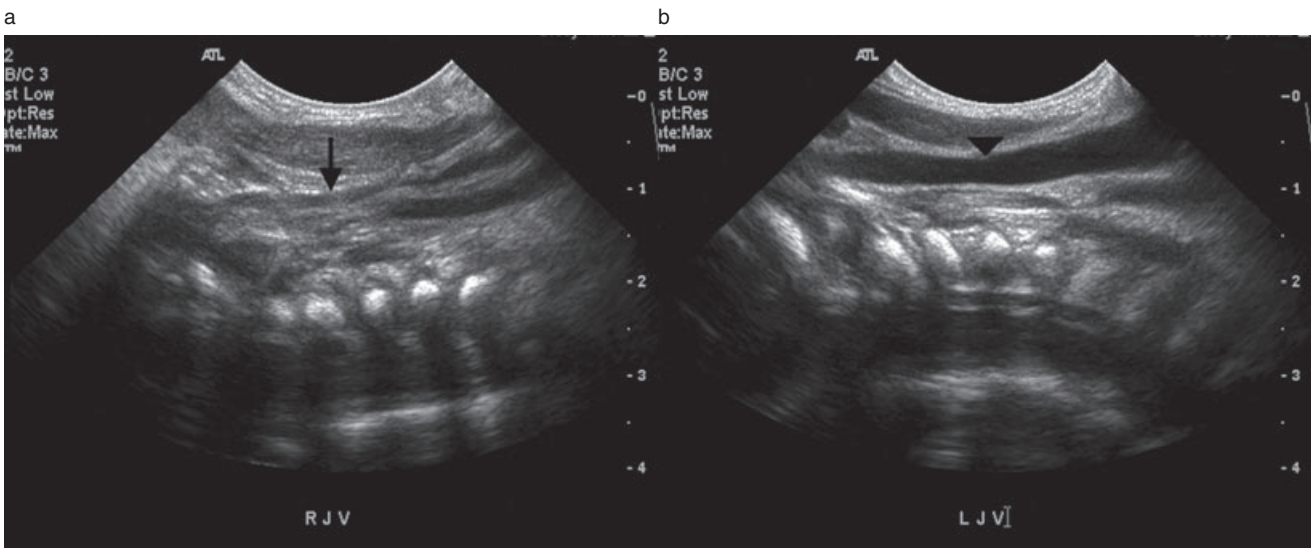

Fig. 1 Reduced diameter of an internal jugular vein (arrow, a) compared with the contralateral internal jugular vein (arrowhead, a). Abnormal compressibility and respiratory variation was also observed.

have a significantly higher rate of septicaemia and thrombosis associated with the use of a Broviac catheter than more mature infants.[8] In addition, neonates are more predisposed to thrombosis than older children because they seem to have a deficiency of thrombin inhibition and relatively deficient fibrolysis.[17] Surgically treated newborns with a CVC, mainly after abdominal surgery, are at high risk of thrombosis because of alterations in the coagulation system and prolonged total parenteral nutrition.[14,18] In our cases, catheter-related infection did not occur, but the majority (20 of 23) of patients were surgically treated. The other possible cause of deformities includes injury of the vein during insertion. Because premature and low-birth-weight neonates have a narrow-diameter IJV, insertion of the CVC requires great technical skill. Even when the catheter is inserted by a well-trained expert, mobilisation and puncture of the IJV have the potential to cause damage.

The duration of catheter use also influences the formation of vein deformities. Although previous reports have shown no

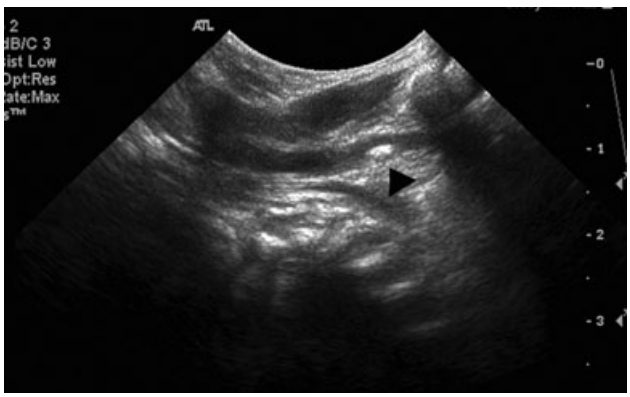

Fig. 2 Echogenic mass on the vein wall (arrowhead).

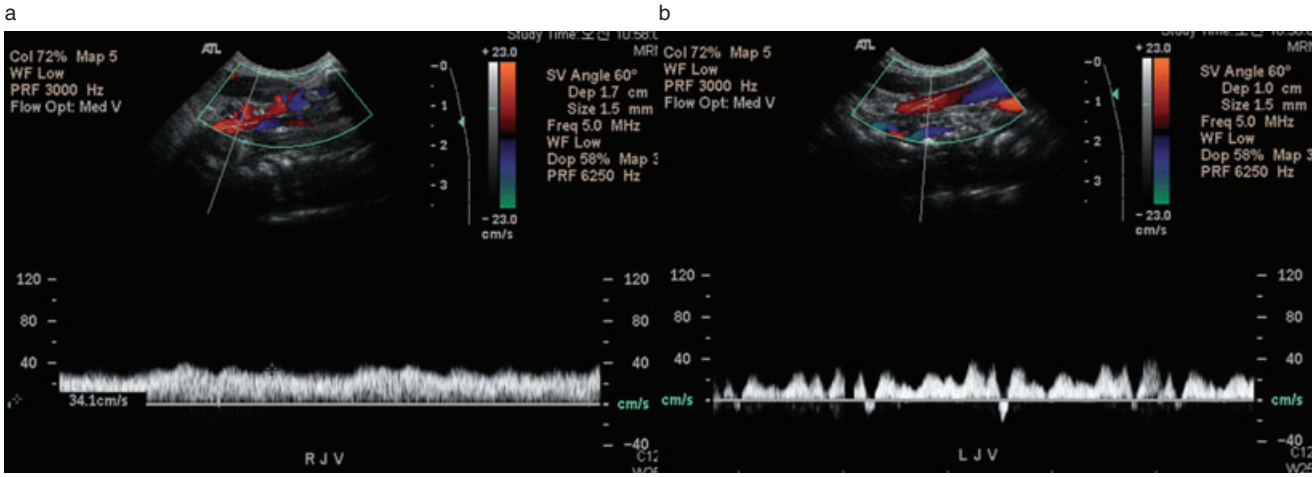

Fig. 3 Pulse wave Doppler study showed abnormal monotonous blood flow waveforms in the right internal jugular vein in which the central venous catheter was placed (a). The normal biphasic blood flow was observed in the contralateral internal jugular vein (b).

Table 3 Summary of the deformity group

Case	1		2		3		4		5		6	
Gestational age (week)	31		26		26		36		28		31	
Age at insertion (day)	3		19		20		1		5		2	
Body Weight at insertion (kg)	1.76		0.91		0.84		2.02		1.12		1.27	
Duration of use (day)	48		56		33		18		82		57	
Doppler Ultrasound	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
• Interval (1st: month, 2nd: year)	2.63	3.74	0.87	3.86	4.67	3.67	0.77	NA	2.30	2.74	1.87	2.55
• Abnormal compressibility and respiratory variation	Yes	Obstruction	No	Yes	Obstruction	Obstruction	Yes	NA	Yes	Obstruction	Yes	Yes
• Echogenic intravascular mass	No		Yes	No			No		Yes		No	No
• Waveform of blood flow (M: monophasic, B: biphasic)	M		B	B			M		M		B	B

NA, not available.

correlation between catheter indwelling time and vein deformities in newborns,[5,15] Salonvaara *et al.*[18] and Ruud *et al.*[19] suggested that the catheter indwelling time may possibly contribute to jugular vein thrombosis. Our data support these results. Catheters are known to be thrombogenic because they damage the vessel wall and disrupt blood flow. Prolonged catheter use for total parenteral nutrition or the administration of IV fluids may promote vessel injury.[20]

Several methods, including venogram, magnetic resonance imaging and Doppler ultrasound, have been introduced to evaluate the vein after catheterisation.[12,19,21,22] Among these, Doppler ultrasound has advantages with respect to accessibility and invasiveness.[21] In Doppler ultrasound, a normal IJV is distensible, and the diameter of the neck vein varies according to patient respiration. Thus, the Doppler flow pattern is usually biphasic.[13] In this study, where normal data for newborns were not available, we adapted the data from previously published criteria[5,11–13] and compared them with data from contralateral normal IJVs because the essential point of Doppler ultrasound evaluation of the IJV is to assess the symmetry of both the vein and blood flow.[13]

This study has the following limitations: we only studied 23 patients, and long-term follow up was confined to the deformity group. The development of abnormalities from IJV that appeared normal on the initial Doppler ultrasound could not be evaluated. Further studies are required to overcome these issues.

However, although sequential follow-up was confined to the few patients in the deformity group, IJV deformities were not improved over time but had a tendency to be aggravated. These results suggest that serial follow-up Doppler ultrasounds are needed to evaluate the risk of vein deformities. In cases of normal IJV after CVC insertion, further Doppler ultrasound is also required to determine whether the morphology of IJV can change after a long-term follow-up period.

The management of catheter-related vein deformities is still not well established. In our study, all cases were subclinical; it is

not clear whether our findings would have revealed clinically significant symptoms. Nevertheless, our results can be applied clinically in cases of recannulation of the IJV. Usually, the right IJV is the preferred insertion site because the procedure is technically easier and has fewer complications. Reusing this IJV has the advantage of preserving other central veins.[11] Awareness of the vein's condition after catheterisation is especially important in newborns because a catheter might need to be reinserted later in life.

Conclusions

Our data demonstrate that a lower gestational age, a lower body weight and more catheter indwelling days are the most significant factors affecting the incidence of venous deformities after central venous catheterisation in neonates. Paediatricians and paediatric surgeons need to be aware of the possibility of deformities to prevent complications related to Broviac catheters. We suggest sequential Doppler ultrasound to evaluate any signs of catheter-related vein deformity.

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