Risk of Systemic Infections Associated with Umbilical Vessel Catheterization

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— The purpose of the present study is to determine the risk of infections associated with umbilical vessel catheterization. During a period of recent four years, 97 catheters were inserted into the umbilical vessels of 94 newborn infants in a newborn nursery. Thirty percent of the catheter tips were colonized upon removal with pathogens (11%) and contaminants. The rate of catheter colonization was not dependent on sex, gestational age, birth weight and duration of catheterization. Bacteria were isolated from blood specimen drawn via the catheter upon removal in one patient, but blood sample from peripheral artery and catheter tip yielded no organisms in this patient. One patient (1%) was found to be septicemic while the catheter was in place. Culture of the catheter tip and blood drawn via the catheter proved unreliable in the diagnosis of subsequent systemic infection. Judicious surveillance for systemic infection by peripheral blood culture is necessary. ——— umbilical vessel catheterization; neonatal systemic infection

In recent years, the usefulness of indwelling umbilical vessel catheter has been established and it has become a common procedure in the management of the acutely ill and high-risk newborn infants. The convenience and advantages of umbilical vessel catheter as stable and durable intravascular route for infusion, monitoring acid-base status and exchange transfusion are obvious as compared with other methods such as scalp vein needle, venous cut down and frequent puncture of peripheral artery. However, there are many reports of complications such as thrombosis, embolization, hemorrhage and infection (Kitterman et al. 1970). We have paid attention to the risk of systemic infections associated with umbilical vessel catheterization, because the umbilicus is almost heavily contaminated at the time of catheter insertion (Fairchild et al. 1958) and newborn infants are particularly prone to infection. This report describes the results of prospective study in newborn patients to define the risk of systemic infection associated with umbilical vessel catheterization. There have been few studies on this problem in

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our country, and so far as we know, this paper is the first report from Japan in this area.

MATERIALS AND METHODS

The subjects of the present study were 94 infants who had umbilical catheterization in the newborn nursery of the Aomori Prefectural Central Hospital from April 1, 1973 to March 31, 1977. All the infants studied were born elsewhere and referred to us because of severe neonatal jaundice, respiratory distress and others. Thirty-eight infants were full term (gestational age; over 37 weeks) and 56 were preterm infants. The apparent discrepancy in total numbers of catheters and patients is due to the fact that more than one catheter were inserted into some infants. The birth weight was over 2500 g in 30 infants, 1500 to 2500 g in 37, and below 1500 g in the remaining 27. All catheterizations were performed by members of house staff. The umbilicus and surrounding skin of the infant were washed first with tincture of iodine followed by 70% alcohol. The umbilical area was kept sterile by a sterile circumcision sheet exposing only the umbilical stump. The operator always used a sterile gown and gloves. The cord was cut 0.5–1.5 cm from the skin-umbilical cord junction, and the radiopaque polyvinyl chloride catheter (end -and-side-hole type, No. 5 or 3.5 French) was inserted into the umbilical vessel. The catheter was then fixed in place with silk thread. A purse-string suture was also placed in Wharton's jelly around the vessel and catheter. The area was covered with a 5×5 cm sterile dry gauze dressing, over which one or two loops of catheter were secured with paper tape. Topical antibiotics was not used. The dressing was not changed until removal of the catheter. Catheter distance were predetermined from graphs prepared from Dunn's post-mortem measurements (Dunn 1966). Final positions were confirmed by anteroposterior and lateral roentgenograms of the chest and abdomen. Infusion was maintained with a constant infusion pump. The indications for placement of catheters in this series were respiratory distress (48%), severe neonatal jaundice (28%), congenital heart disease (6%) and others (18%). Systemic antibiotics were not routinely administered to all patients with umbilical vessel catheterization, and the patients who were administered systemic antibiotics were excluded from this study because the duration and route of administration, and doses and sort of antibiotics were not controlled. When conditions allowed of removal of the catheter, the following procedures were performed according to the study protocol. First, a peripheral blood culture was obtained from the radial artery after sterilizing the skin with alcohol. A blood sample was then obtained via the umbilical catheter (cord blood) for culture. Finally, the catheter was then carefully withdrawn to avoid contamination and the catheter tip was smeared on the McConkey's and blood agar plates. The catheter tip cultures were read at 24 and 48 hr and blood cultures were examined daily for at least 10 days. All cultures were processed by the Diagnostic Bacteriology Laboratory and the standard method for identification of aerobic and anaerobic organisms were employed. If an infant died, the catheter was always left in situ so that changes related to the catheter could be seen at postmortem examination. Catheter tip cultures were done in the autopsy room by the same manner as mentioned above. Blood cultures were obtained by cardiac puncture. Pertinent clinical data were recorded on each patient. These included birth weight, age of gestation, sex differentiation, and duration of catheterization. A comparison was made between these parameters and the results of cultures to determine some consistent relationship.

RESULTS

Some of the 94 patients had both vein- and artery-catheterization concurrently or serially, and a total of 97 catheters, 33 arterial and 64 venous, were placed in 94 patients. Twenty-three infants died, and autopsies were performed in 78% of them. Complications probably related to the umbilical vessel catheteriza-

TABLE 1. *Organisms recovered from culture of catheter tip*

Organism	No. of isolates	
	Artery	Vein
Pathogen;		
<i>S. aureus</i>	1	4
<i>E. coli</i>	0	1
<i>Pseudomonas</i>	0	1
<i>Proteus</i>	1	1
<i>Enterobacter</i>	0	1
<i>Enterococcus</i>	0	1
Contaminant;		
<i>S. epidermidis</i>	1	2
<i>Mima polymorpha</i>	0	3
Others	4	8

tion were found in 2 of the 18 autopsy cases. In the remaining 16 cases, no complication was found.

A total of 97 catheter tip cultures were obtained from the babies studied. Seven of 33 arterial catheter tip cultures (21%) and 22 of 64 venous catheter tip cultures (34%) demonstrated bacterial growth. The other 70 catheters were negative.

Table 1 shows the type of bacteria isolated from catheter tips in both umbilical vessels. The organisms isolated were divided into the so-called pathogens (coagulase-positive staphylococcus, *Escherichia coli*, *pseudomonas*, *proteus*, *enterobacter*, and *enterococcus*) and the contaminants (coagulase-negative staphylococcus, *Mima polymorpha*, and others) based on the studies by Zinner et al. (1969), Nordin (1969), and Balagtas et al. (1971). Eleven percent of the catheter tips were colonized with pathogens and 19% with contaminants by this classification. The most frequently isolated organisms were coagulase-negative and coagulase-positive staphylococci, which accounted for 28% of all the positive cultures. In all of the instances the positive catheter tip cultures yielded a single bacterial genus. There was no statistical difference either in colonization rate or in the incidence of pathogens and contaminants between arterial and venous routes.

The sex distribution in relation to the results of umbilical tip cultures in artery and vein are shown in Table 2. The sex of the newborn infants did not affect the colonization rate in both vessels (χ^2 with Yates' correction; 0.86 in artery, 0.11 in vein, $p > 0.25$). The colonization rate of arterial catheter tip in females appeared to be low as compared with that in males; however, this difference was not

TABLE 2. *Results of Catheter tip cultures and sex distribution*

Umbilical vessel	Result of culture	No. of cases	Male	Female
Artery	+	7	6	1
	—	26	15	11
Vein	+	22	13	9
	—	42	23	19

TABLE 3. *Results of catheter tip culture and birth weight of the patients*

Birth weight(g)	Artery		Vein		Total
	+	—	+	—	
<1500	4	12	4	9	29
1500-2500	3	10	5	20	38
≥2500	0	4	13	13	30

TABLE 4. *Results of catheter tip cultures and gestational age of the patients*

Gestational age (week)	Artery		Vein		Total
	+	—	+	—	
≤30	3	11	4	11	29
31-36	3	10	6	11	30
≥37	0	6	13	19	38

TABLE 5. *The yearly change of average indwelling time of umbilical catheter*

Year	Artery	Vein
	days	days
1973	—	4.9
1974	5.2	5.4
1975	3.7	3.4
1976	5.0	1.7
1977	4.1	0.75

statistically significant.

Table 3 shows the birth weight in relation to the results of umbilical tip cultures in artery and vein. No correlation was found between birth weight and the incidence of positive tip cultures in both vessels ($\chi^2=1.24$ in artery, $p>0.25$; 5.18 in vein, $0.02<p<0.025$)

The gestational age in relation to the results of umbilical tip cultures in artery and vein are shown in Table 4. There was no significant difference in the frequency of positive cultures among the three groups of different gestational age in both vessels ($\chi^2=1.64$ in artery, 0.87 in vein, $p>0.20$).

Age at the time of catheterization ranged from 30 min to 7 days. The duration of catheterization was 2 to 4 days in 32% of the cases, more than 4 days in 40%, and less than 48 hr in 28%. The longest was 12 days of serial 2 catheters in one patient. The average indwelling time was 104 hr in artery and 92 hr in vein, and there was definite trend to diminish the duration of catheterization year by year (Table 5).

Table 6 shows the duration of catheterization in relation to the results of umbilical tip cultures in artery and vein. The rate of catheter colonization was

TABLE 6. *Results of catheter tip cultures and duration of catheterization*

Duration (hr)	Artery		Vein		Total
	+	-	+	-	
≤48	1	6	7	13	27
49- 72	2	5	3	10	20
73- 96	1	4	2	4	11
97-120	0	4	4	5	13
≥121	3	7	6	10	26

TABLE 7. *The incidence of pathogen and contaminant recovered from the catheter tip*

Result of culture	Days of catheterization					Total
	≤2	2-3	3-4	4-5	5<	
No growth	19	15	8	9	17	68(70.1%)
"Contaminant"	6	1	1	3	8	19(19.6%)
"Pathogen"	2	4	2	1	1	10(10.3%)
Total	27	20	11	13	26	97

not dependent on duration of catheterization in both vessels ($\chi^2=1.97$ in artery, 1.22 in vein, $p>0.10$).

The incidence of pathogens and contaminants recovered from the catheter tips in relation to the duration of catheterization are shown in Table 7. The duration of catheterization did not influence the incidence of pathogens and contaminants cultured ($\chi^2=8.61$, D.F.=8, $p>0.20$).

A total of 19 pairs of cultures of the cord blood and peripheral blood obtained from the radial artery in 18 patients were processed. Nine patients had arterial catheterization and 9 had venous catheterization. *Staphylococcus epidermidis* was recovered from the cord blood of one infants (5%), but the blood from the radial artery and the catheter tip were negative in this patient. This infant was full-term and had venous catheterization for 40 hr because of severe neonatal jaundice. The patient was clinically well and did not develop septicemia. Eighteen cord blood cultures from 17 other infants remained sterile. No blood sample taken from the radial artery yielded any organisms in these cases.

A serious complication, causing or contributing to death, was found at autopsy in two patients as mentioned before. A septic complication occurred in only one infant (1%), a preterm baby who had umbilical artery catheterization for respiratory distress syndrome. *Staphylococcus aureus* was recovered from the catheter tip and blood obtained from the radial artery. Cord blood culture was not done in this case. The autopsy showed abscesses in the lungs and liver. Another patient in whom the catheter was the likely cause of death was a full-term baby with Down's syndrome and had umbilical venous catheterization for severe neonatal jaundice. Periumbilical abscess occurred in this patient 3 days after withdrawal

of the catheter, and symptoms of peritonitis developed. The patient recovered once; however, death occurred at age of 4 months due to ileus. The autopsy revealed strangulation ileus of the jejunum. Catheter tip culture was negative in this patient.

DISCUSSION

It is well known that the umbilical catheter provides a frequent portal of entry for bacteria into the blood of the newborn. During the past several years, numerous reports have attested to the hazards of prolonged umbilical vessel catheterization. Many authors investigated the risk of systemic infection associated with umbilical vessel catheterization by using umbilical catheter tip cultures. Table 8 shows the reported experiences of tip cultures by other authors. The colonization rate reported by Krauss et al. (1970) and Symansky and Fox (1972) represents two ends of spectrum in non-antibiotics group of infants. The reported incidence varied widely. In our study the incidence of positive catheter tip lies between the two ends of spectrum. As mentioned in other studies, no relation was found between the the incidence of bacterial contamination and several parameters such as duration of catheterization, gestational age and birth weight of infants. The influence of systemic antibiotics on catheter colonization rate was not definite and stable in other studies (Krauss et al. 1970; Balagtas et al. 1971; Powers and Tooley 1972; Bard et al. 1973; Anagnostakis et al. 1975). Powers and Tooley (1972) stated that the incidence of contamination of umbilical vessel catheter varies in accordance with the technique used as well as the care and experience of the personnel. Balagtas et al. (1971) also stated that contamination of catheter occurs regularly during catheter insertion with organism from the cord stump which is colonized with

TABLE 8. *Reported experiences of catheter tip culture*

Authors	Antibiotics employed	Artery or vein	Percentage of positive catheter tip culture	
			A.B (+)	A.B (—)
Krauss 1970	ABPC+KM	A & V	70.0%	75.0%
Casalino 1971	ABPC+KM	A & V	5.0	
Balagtas 1791	ABPC+KM	V	33.3	70.5
Johns 1972		A & V		10.9
Symansky 1972		A		6.3
		V		2.3
Powers 1972	ABPC+KM	A	9.6	7.6
Bard 1973	ABPC+KM	A	24.2	54.3
Daschner 1974		A		3.1
		V		23.4
Franke 1974	ABPC, CET+CL	A	5.5	
Anagnostakis 1975	PC+KM	V	60.0	63.0
Present study 1977		A		21.2
		V		34.3

A.B (+); Antibiotics treated group

A.B (—); Antibiotics non-treated group

bacteria soon after birth. In this regard, it is now suggested that catheter tip colonization is worthless by itself in evaluation of bacterial infection of infants. The diagnosis of neonatal septicemia should be ultimately based on a positive blood culture.

Cowett et al. (1976) compared the colonization rate of peripheral blood with those obtained from the umbilical artery and found a close correlation. On the other hand, several authors reported some differences in the results of cultures from the two samples (Vidyasagar et al. 1970; Balagtas et al. 1971; Powers and Tooley 1972). In our series, cord blood culture was positive in one patient, while the peripheral blood was negative. It is now well accepted that peripheral blood cultures are necessary to evaluate the presence of systemic infection in patients under umbilical vessel catheterization.

The reported rates of septicemia associated with umbilical catheterization ranged from zero to several percent (Vidyasagar et al. 1970; Balagtas et al. 1971). The prevalence of septicemia in our study was 1%. Thus, the septicemia associated with umbilical catheterization is never a negligible incidence. It must be emphasized that judicious surveillance for systemic infection is necessary for the patients under umbilical catheterization.

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