

## Original articles

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## Umbilical artery catheters: High, low, or no

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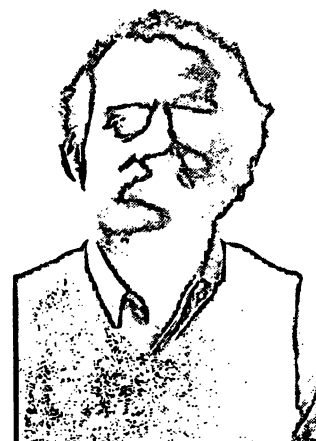
Catheterization of the newborn umbilical artery has become a common practice. Size and accessibility of the vessel allows routine sampling of arterial blood, infusion of fluids and pharmacologic agents, and blood pressure monitoring. Many complications from this procedure have been reported, however, and arterial thrombosis may pose a significant threat. Post-mortem examinations have shown an incidence of thrombotic complications ranging from 8.6% to 58% [2, 6, 11, 15, 17, 18]. In recent years NEAL et al. [11] and GOETZMAN et al. [6] demonstrated thrombus formation with aortography in 95% and 24% of catheterized patients respectively.

Optimum placement site for the catheter tip has remained a controversial subject. Several authors have recommended placement well below the origin of major renal and mesenteric arteries [6, 11, 17]. Others recommend placement above the origin of the celiac plexus [1], while others recommend either of the above [7].

The newborn intensive care service at the Dartmouth-Hitchcock Medical Center reviewed its policy for placement of catheters in late 1974. Concern with possible complications, especially necrotizing enterocolitis, led to a change in the prior practice of placing the catheter tip either above the celiac axis (high placement) or below the inferior mesenteric artery (low placement). For a period of time all catheters were placed in a low position. Because of the distinct impression of increased complications with low placement, a

### Curriculum vitae

MARK STEVEN HARRIS was born in 1948. He obtained his B.S., Biology 1970 at the Buchnell University in Lewisburg, Pennsylvania, his M.D. 1974 at the Georgetown University, Washington. 1974-1975 Internship in Pediatrics at the Mary Hitchcock Memorial Hospital, Hanover, Hampshire. July-October 1976 study of Danish and Swedish Child Health Care at the University of Copenhagen, Institute of Social Medicine.



prospective study comparing complications observed with high and low catheter placement was designed.

Two previous studies comparing the two sites have been presented in abstracts. JACOB et al. [9] reported a retrospective study in which there was a greater incidence of complications with low placement (63% vs. 21%); FEINAUER et al. [5] reported a greater incidence of peripheral vascular complications with low placement (28% vs. 7%), but also noted that necrotizing enterocolitis or signs associated with that disease occurred in 24% of the high placement group.

### 1 Methods

Neonates admitted to the intensive care unit who were having significant respiratory distress or who

were considered to be at high risk for developing respiratory problems had umbilical artery catheters inserted. They were divided into two prospective groups by alternating high and low placement. Catheters were inserted by the pediatric housestaff all of whom are at the PL-1 or PL-2 resident level.

Catheterization was performed under strict sterile technique with the umbilicus and surrounding abdominal wall prepped with Povidoneiodine solution (Betadine®) and carefully draped. The umbilical cord was severed 0.5 to 1.0 cm from the skin and the umbilical artery lumen identified and carefully dilated with an iris forceps. Sterile polyvinyl end-hold umbilical catheters, size 3.5 or 5.0 French, with radio-opaque marker\* were inserted. Data of PHELPS et al. was utilized to determine probable level of origin of major vessels [12]. Placement was defined utilizing DUNN's relationship between shoulder-umbilicus length and the catheter length [4]. High placements were confirmed to be at vertebral level T-11 or above and low placements at level L-4 or L-5 by x-ray. The catheter was secured with tape and occasionally a suture through WHARTON's Jelly, and a sterile three-way stop-cock attached. A constant pump infusion of Dextrose and water containing 1 unit of Sodium Heparin per 5 cc of solution was started. The catheters were used to obtain blood samples, infuse fluids and electrolytes including sodium bicarbonate and calcium gluconate, administer blood transfusions, and give antibiotics if indicated.

Birth weight and gestational age, time from birth of catheter placement, and size of catheter were recorded for each patient. Nurses and physicians were instructed to record any problem, and specific attention was directed toward blanching, cyanosis or hyperemia of the lower part of the body, glucosuria, feeding difficulties, or abdominal distention. Dextrostix® screening was performed when glucosuria appeared. Persistent cyanosis or blanching of all or part of a lower extremity was treated by warming the contralateral extremity. If normal color did not return within several minutes the catheter was removed. At least once during each day catheterized babies and their

records were checked by one of the authors. Details regarding complications recorded by other individuals were followed up at that time.

## 2 Results

A total of 36 patients were studied with 18 in each group. Tables I and II give general characteristics of complications observed in individual neonates. There was no statistical difference between the groups by birth weight, gestational age, age at insertion, length of time the catheter was in place, or types of infusate administered.

There was a statistically significant ( $p < 0.005$ ) difference in the incidence of clinically apparent peripheral vascular complications; 67% of the low placement group versus 17% of the high group had recorded findings. Of the total of 15 neonates with these findings, 6 had cyanosis and/or blanching which resolved with either position change or warming of the contralateral leg, while 9 required removal of the catheter. All surviving patients had eventual resolution of cyanosis and/or blanching. 5 in each group died; 3 of 5 low group and 1 of 5 high group deaths had recorded peripheral complications.

One patient with a high catheter developed necrotizing enterocolitis diagnosed 15 hours after the catheter was removed.

12 of 15 patients had peripheral vascular complications which were unilateral only. The catheter was traversing the ipsilateral arteries in 8 and the contralateral in 4. The smaller sized catheter was associated with a higher complication ratio. There was no statistical difference between the complication and no complication groups by birth-weight and gestational age, age at insertion, duration of catheterization, catheter size or infusates (Tab. III).

## 3 Discussion

This study provided disquieting data which did not completely clarify the issue of high or low placement for an umbilical artery catheter.

The investigation was originally stimulated by concern regarding necrotizing enterocolitis (NEC) and possible association with catheters especially

\* Argyl Umbilical Catheters, Sherwood Medical Industries, Inc., St. Louis, Missouri.

Tab. I. Low placement group.

Pt. No.	Birthweight/ gestational age (Gms/Wks)	Age at insertion/ duration of catherter- ization (Hrs/Hrs)	Catheter size (Fr.)	Calcium gluconate/ sodium bicarbonate	Antibiotics/ whole blood	Complications
1	3170/38	21/110	3.5	++	++	(1) Cyanosis L leg at 93°
2	850/28	8/33	3.5	++	++	(2) Blanching L leg at 33° Catheter out
3	1400/32	59/70	3.5	-/+	++	(3) Blanching and cyanosis both legs at 36°
4	1235/30	7/50	5	-/-	-/-	
5	1190/30	7/70	5	+/-	++	
6	790/28	1/7	3.5	-/+	-/-	(6) Cyanosis L leg at 6°
7	2050/32	7/97	5	-/+	++	
8	880/30	8/65	3.5	++	+/-	(8) Cyanosis L toes at 2°
9	2030/34	3/84	5	++	++	
10	2100/36	3/75	3.5	++	++	(10) Cyanosis R leg at 75° Catheter out
11	2100/36	9/6	5	-/+	-/-	
12	2180/34	5/52	5	++	++	(12) Cyanosis R leg at 52° Catheter out
13	2025/34	3/57	3.5	++	++	(13) Blanching and cyanosis both legs at 50° - Catheter out
14	1880/32	5/80	3.5	-/+	++	
15	2400/36	15/69	3.5	+/-	++	(14) Blanching and cyanosis R foot at 80°-Catheter out
16	1470/30	1/77	3.5	++	++	(15) Cyanosis R foot at 69° Catheter out
17	2150/36	13/44	3.5	++	++	(16) Cyanosis R foot at 77° Catheter out
18	1680/35	14/25	5	-/-	+/-	(17) Cyanosis and edema R foot at 44° - Catheter out
Mean:	1753/32.8	10.5/59.4				
S.D.:	604/2.9	12.8/27.7				

Tab. II. High placement group.

Pt. No.	Birthweight/ gestational age (Gms/Wks)	Age at insertion/ duration of catherter- ization (Hrs/Hrs)	Catheter size (Fr.)	Calcium gluconate/ sodium bicarbonate	Antibiotics/ whole blood	Complications
1	2300/35	7/84	5	+/-	-/+	(1) Cyanosis L toes at 26°
2	1600/32	9/156	3.5	++	++	
3	2325/35	19/71	5	++	++	
4	1645/34	6/49	5	++	++	
5	1240/30	1/28	5	++	+/-	
6	1843/34	6/54	5	-/+	-/-	
7	795/27	1/45	3.5	++	++	(7) Cyanosis both legs at 45° - Catheter out
8	3200/36	5/94	5	++	++	
9	2200/34	8/118	3.5	++	++	(9) Cyanosis R leg at 80°
10	1130/30	1/23	3.5	-/-	-/-	
11	2780/30	1/3	5	-/-	-/-	
12	1790/32	9/85	5	+/-	++	(12) NEC at 100°
13	1720/38	5/140	3.5	-/-	++	
14	3100/38	12/19	5	-/-	+/-	
15	665/25	1/112	3.5	++	++	
16	2150/33	4/38	3.5	++	+/-	
17	3570/34	5/38	5	-/-	++	
18	910/29	1/116	3.5	++	++	
Mean:	1887/32.5	5.6/70.7				
S.D.:	738/3.4	4.6/43.4				

those in high position. Incidence of NEC in our service has been sporadic with 7 cases in approximately 350 admissions over two years. Of these 7, 5 did not have UA catheters; of the 2 who did, both were high. The one case of NEC in our study population was in the high group but obviously a relationship cannot be assumed.

The cause of the increased incidence of recorded peripheral complications with low placement is unclear. In addition, there appears to be a higher incidence of complications with the smaller catheter. As Fig. 1 and Tab. I and II indicate, the two groups appear well balanced for factors such as birth weight and gestational age, deaths, time and duration of catheterization, and infusates.

The complications were often transitory and responded to conservative therapy and the possibility that these might represent thromboembolic

phenomenon led to a review of heparin use in previous studies. While the amount of heparin used in our protocol was less than that recommended by some authorities, there is in fact no clear evidence of decreased thrombus formation with heparinization.

Other possibilities for the increased difficulties with low placement include the relative concentration of infusate in arterial blood and movement of the catheter tip. Infusion rates varied widely within both study groups but the low placement patients have less dilution with arterial blood than high placement due to lower total flow volume in the distal aorta. Hyperosmolar solutions may, therefore, be more of a problem with low placement. Infusion of hyperosmolar solutions through an umbilical arterial catheter is not accepted universally; many units utilize a peripheral vein. However,

Tab. III.

	Mean birthweight/gestational age (Gms/Wks)	Mean age at insertion/duration of catheterization (Hrs/Hrs)	Size of catheter (French)		Infusates			
			3.5	5.0	calcium gluconate	sodium bicarbonate	anti-biotics	whole blood
Complications (15)	1773/32.7	10.4/60.1	13	2	12	13	13	13
No complications (21)	1855/32.7	6.3/64.6	6	15	11	12	16	12

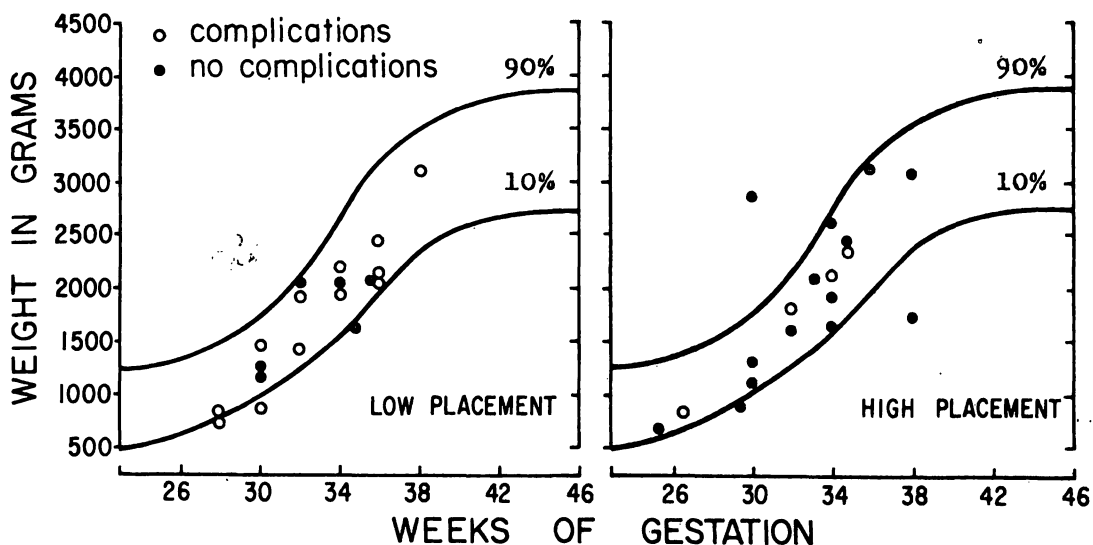


Fig. 1. High and low placement patients plotted on birthweight/gestational age graphs derived from LUBCHENCO et al [10]. The upper and lower lines on the graph represent the 90th and 10th percentiles, respectively.

infusing these hyperosmolar solutions through the umbilical arterial catheter is the routine in our unit and in many units in the United States.

We speculate that movement of a semi-rigid plastic catheter tip during systemic pulse pressure variation could lead to local irritation and reflex vasomotor changes observed in the lower extremities. There were no gross anatomical changes observed in autopsied infants.

The physician and nursing team caring for patients in our intensive care unit has, after the completion of this study, expressed a preference for high placement. The consensus is that the number of physical manifestations seen in patients with low catheters and the inconvenience and disruption of orderly care which results from necessary steps to deal with these complications is undesirable. Our policy is to remove a catheter when complications are not remedied by change of position of the newborn, short term warming of the contralateral extremity or cessation of infusion of high osmolar solutions. When indicated by the clinical situation, insertion of a catheter through the other artery is attempted.

The results of this study have led us to evaluate other means of obtaining adequate specimens for determination of blood gases. Use of an indwelling percutaneous radial artery catheter in the right arm in conjunction with a peripheral IV has been suggested [16]. We have found this method to be satisfactory in some cases and have not had complications in our small series to date. We have employed on occasion an indwelling temporal artery butterfly needle as discussed by SCHLEUTER et al [13].

### Summary

Catheterization of the umbilical artery is a common practice. Complications are varied with thrombosis a significant threat. Optimum placement site for the catheter tip is controversial with placement above the celiac plexus recommended by some authors and below the major renal and mesenteric recommended by others.

This study was designed following a change in placement procedure at the authors' institution. Concern over possible complications of high placement, especially necrotizing enterocolitis, led to a period when all catheters were placed in a low (below the inferior mesenteric artery) position. Our impression of increased vasomotor complications led to a prospective study.

Alternatives available in the immediately foreseeable future include catheter-tip electrodes such as that described by CONWAY et al [3] and the HUCHS' transcutaneous oxygen system ( $Tc_{PO_2}$ ) [8, 14] which does not require a catheter. Complications associated with the catheter tip electrode probably include at a minimum those associated with catheters. At present  $Tc_{PO_2}$  monitoring requires pH and blood pressure monitoring by other techniques. However, the reported reliability and lack of complications associated with the  $Tc_{PO_2}$  system might make umbilical catheterization less routine.

Our study and the literature confirm that umbilical catheterization is far from benign. Furthermore, while low placement of the catheter tip might be desirable for theoretical reasons our study suggests that there are significantly more observed peripheral findings which lead to intervention and disruption of care. In our opinion the question of cause and effect between umbilical artery catheters and NEC is still open.

At present we are caught by data and observations which suggest that: (1) high placement, preferably with a large (5F) catheter, gives the least short term disruption of care but has theoretical shortcomings, (2) low placement has less theoretical concern but definitely has more complications leading to disruption of care than high placement, and (3) no placement or no catheter is an alternative becoming increasingly feasible as technology and clinical trials develop safe, reliable new means of infusion and blood gas determination.

Alternating high (above the celiac axis) and low placement of catheters under sterile technique was performed. Standard techniques for x-ray determination of placement level, securing of the catheter, and infusion of solutions were employed. Problems were recorded by personnel on the unit with patients and records checked by the authors daily. Birthweight and gestational age, time of catheterization and size were recorded.

Results were obtained for a total of 36 patients with 18 in each group. There was no statistical difference between the groups for birthweight, gestational age, age at insertion, length of time the catheter was in place or infusate. A statistically significant ( $p < 0.005$ ) difference in incidence

of apparent vasomotor complications was recognized, with the low placement group having the higher rate 67% vs. 17%). Smaller size catheters, 3.5 French, were noted to have a higher complication rate than 5.0 French lines regardless of placement.

The study did not resolve an initial concern whether necrotizing enterocolitis is associated with high placement. Only one case of NEC occurred and was documented 15 hours after the removal of a high catheter. Intensive care personnel, upon completion of the study, expressed a preference for high placement because of a consensus that

inconvenience and disruption of care associated with low placement is undesirable. However, concern over embolic or vasomotor complications in mesenteric or renal vessels was not alleviated by the study.

This study suggests that neither high nor low placement is a completely acceptable alternative. This has led to active evaluation and use of radial and temporal indwelling arterial lines when feasible. Furthermore, the study suggests that other alternatives, such as the HUCHS transcutaneous oxygen electrode system, should be actively pursued.

**Keywords:** Newborn intensive care, oxygen monitoring, umbilical catheters.

### Zusammenfassung

**Katheterismus der Umbilicalarterie: Hohe oder tiefe Platzierung oder überhaupt kein Katheterismus**

Die Katheterisierung der Umbilicalarterie ist eine allgemein durchgeführte Maßnahme. Die möglichen Komplikationen sind vielfältig, wobei die Thrombosierung ein erhebliches Gefahrenmoment darstellt. Es besteht keine einheitliche Meinung hinsichtlich der optimalen Platzierung der Katheterspitze; einige Autoren plädieren für eine Platzierung der Spitze oberhalb des truncus coeliacus, andere fordern eine Lagerung der Katheterspitze unterhalb der Vasa renalia und Vasa mesentericae.

Diese Untersuchung wurde in der Abteilung des Autors durchgeführt, nachdem eine Veränderung in der Katheter-vorschubtechnik herbeigeführt worden war. Die Beachtung möglicher Komplikationen bei hoher Katheterlage, insbesondere die nekrotisierende Enterokolitis, führten zu einer Periode, in der alle Katheter tief eingeführt wurden (unterhalb der Arteria mesenterica inferior). Unsere Beobachtung über gehäufte vasomotorische Komplikationen führten zu einer prospektiven Studie.

Es wurden alternierend hohe (oberhalb des truncus coeliacus) und tiefe Platzierungen des Katheters unter sterilen Bedingungen durchgeführt. Es wurden weiterhin Standardtechniken für die röntgenologische Kontrolle der Lage der Katheterspitze, für die Sicherung des Katheters und eine Standardisierung der verwendeten Infusionslösungen entwickelt und angewandt. Auftauchende Probleme wurden von dem Pflegepersonal der Einheit registriert; die Patienten und die Aufzeichnungen ihrerseits wurden von den Autoren täglich überwacht. Geburtsgewicht und Gestationsdauer, Zeit des Katheterismus und Größe des Katheters wurden ebenfalls registriert.

Die Ergebnisse wurden von insgesamt 36 Patientinnen mit jeweils 18 Probanden pro Gruppe gewonnen. Es fand sich

keine statistische Differenz zwischen den Gruppen hinsichtlich des Geburtsgewichtes, der Gestationszeit, Alter beim Katheterismus, der Zeitdauer mit Katheter in situ und den verwendeten Infusionslösungen. Es fand sich jedoch eine statistisch signifikante ( $p < 0.005$ ) Differenz in der Häufigkeit von offenbar vasomotorischen Komplikationen, wobei die Gruppe mit tiefliegender Katheterspitze die höhere Rate aufwies (37% : 17%). Kleine Katheter (3,5 French) zeigten eine höhere Komplikationsrate als stärkere Katheter mit 5,0 French, unabhängig von der Höhe der Lagerung der Katheterspitze.

Aus der Studie ging nicht eindeutig hervor, ob die nekrotisierende Enterokolitis mit der hohen Katheterlagerung gehäuft assoziiert ist. Es fand sich nur ein Fall von nekrotisierender Enterokolitis, der 15 Stunden nach Entfernung eines hochliegenden Katheters aufgetreten war. Das Intensivpflegepersonal sprach sich gegen Ende der Studie für eine hohe Lage des Katheters auf, mit der einheitlichen Begründung, daß die mit dem tiefen Kathetervorschub verbundenen Unbequemlichkeiten und Unterbrechung der Pflege nicht wünschenswert seien. In dieser Studie fand sich jedoch keine Beobachtung über embolische oder vasomotorische Komplikationen in den Mesenterialgefäßen oder den Vasa renalia.

Diese Untersuchungen lassen vermuten, daß weder die hohe noch die tiefe Lagerung des Katheters eine ganz annehmbare Alternative ist. Dies hat uns zur aktiven Überprüfung der Verwendung von arteriellen Zugängen zur Arteria radialis und temporalis geführt. Die Studie führt weiterhin zu der Vermutung, daß andere Alternativmethoden, wie z. B. das transkutane Sauerstoffelektroden-system nach HUCH weiterhin aktiv verfolgt werden soll.

**Schlüsselwörter:** Nabelarterienkatheterismus, Neugeborenenintensivpflege, Sauerstoffüberwachung

### Résumé

**Les cathéters de l'artère ombilicale: En haut, en bas, ou supprimés**

La cathétérisation de l'artère ombilicale est d'un usage courant. Elle peut entraîner diverses complications dont, notamment, la thrombose. Certains auteurs recommandent l'emplacement optimal de la pointe du cathéter au-dessus

du plexus coeliaque, d'autres au-dessous du plexus rénal et mésentérique supérieur.

Cette étude a été effectuée à la suite d'un changement de la méthode de placement à l'institution des auteurs. Des inquiétudes causées par des complications possibles du placement assez haut du cathéter, en particulier

l'entérocolite nécrotisante, ont amené pendant un certain temps à placer tous les cathéters à un niveau assez bas (au-dessous de l'artère mésentérique inférieure). Soupçonnant alors un accroissement des complications vasomotrices, nous avons décidé de procéder à une étude prospective.

Nous avons placé des cathéters alternativement en haut (au-dessus de l'axe coeliaque) et en bas, dans des conditions parfaitement stériles. Nous avons employé les techniques types de détermination radiographique du niveau d'emplacement, d'assurance du cathéter et d'infusion des solutions. Chaque jour, le personnel du service des malades en question a noté les problèmes se posant et les auteurs ont vérifié les données enregistrées. Furent consignés le poids à la naissance, l'âge de gestation, le temps de cathétérisation et la taille du cathéter.

L'étude a porté sur 36 parturientes réparties en deux groupes de 18 chacun. Nous n'avons relevé aucune différence entre les groupes en ce qui concerne le poids à la naissance, l'âge de gestation, l'âge à l'insertion et la durée où le cathéter a été en place. Par contre, une différence statistiquement importante ( $p < 0.005$ ) a été relevée dans l'incidence des complications vasomotrices apparentes, le groupe à emplacement bas ayant enregistré le taux le plus

élevé (67% contre 17%). Nous avons aussi relevé un taux de complication plus élevé pour les cathéters de taille plus petite, les «3.5 French», que pour les «5.0 French lines», et cela indépendamment de l'emplacement.

Notre étude n'a pas réussi à résoudre le problème d'une corrélation éventuelle de l'entérocolite nécrotisante avec l'emplacement «en haut». Un seul cas s'est produit et a été enregistré 15 heures après le retrait d'un cathéter placé «en haut». En complément de l'étude, le personnel du service des soins intensifs a marqué une préférence pour la position «en haut» afin de réduire les inconvénients et l'interruption des soins associés à l'emplacement inférieur. Cependant, nous ne sommes pas parvenus au cours de nos examens à atténuer nos préoccupations causées par les complications emboliques ou vasomotrices dans les vaisseaux mésentériques ou rénaux.

Cette étude donne à penser que ni l'emplacement à niveau supérieur, ni celui à un niveau inférieur n'offre une alternative parfaitement acceptable, ce qui a conduit à une évaluation active et à l'emploi si possible de lignes artérielles permanentes radiales et temporales. Par ailleurs, elle permet de recommander la recherche active d'autres alternatives comme le système d'électrode à oxygène transdermique de HUCH.

**Mots-clés:** Cathéters ombilicaux, moniteur d'oxygène, soins intensifs aux nouveaux-nés

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