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Position of the umbilical venous catheter in neonatal resuscitation

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Abstract.
The article summarizes many years of experience with radiographs in the neonatal intensive care unit (ICU), provides criteria for the correct and acceptable position of the umbilical venous catheter (UVC). Of the 180 cases observed by the authors, images of 16 clinical cases with incorrectly set UVC, were selected and presented in the article. All radiographs shown are classified depending on the depth of insertion and inadmissible location of the catheter; rationale and interpretation of images are given, with an explanation of possible complications in each case. Based on the above material, the need for "input control" upon admission of a newborn from the maternity ward (transfer to a specialized hospital) was proved in order to prevent the development of complications: pulmonary embolism, iatrogeny.

Keywords:
Neonatology
X-ray
umbilical venous catheter (UVC) migration
iatrogeny

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Introduction

Knowledge of the features of the anatomy and physiology of newborns, a clear understanding of intrauterine communicants in newborns of the first days of life makes special demands on the installation of catheters and their care.

Many years of experience in the radiology department of a children's hospital, which includes the intensive care unit for newborns, has shown that doctors of related specialties (in particular, resuscitators-neonatologists) do not always timely and consistently relate to the routine procedure for installing an umbilical venous catheter (UVC) and caring for it. Evaluation of the correct position and patency of the device largely determines the effectiveness of the therapy received by the newborn. Incorrect placement of the catheter is the most common complication determined on radiographs, with the frequency ranging from 19.4% to 48% [1, 2]. If the catheter is in the wrong position, serious complications can develop, up to a fatal outcome. X-ray, timely and correctly performed in the neonatal resuscitation, plays a crucial role [3].

According to the literature [4, 5], up to 27% of newly placed umbilical venous catheters were placed incorrectly, while only 6% of abnormalities caused radiologically detectable complications. According to other studies, in 78.8% of patients, primary radiography revealed an incorrect position of the UVC.

The efficiency and safety of not only any device (including UVC) is associated with an understanding of the uniqueness of the anatomy of the newborn and the peculiarities of UVC functioning.

Complications associated with UVC include: lack/violation of drug delivery, development of hepatitis, liver injury, development of thrombosis syndrome up to pulmonary embolism (PE), tamponade of the cardiac chambers, mesenteric vein thrombosis with possible thrombus migration. And infusion of hypertonic solution into the liver can significantly damage the parenchyma up to necrosis [6, 7, 8].

In our practice, after the introduction of a local algorithm for UVC control in the neonatal intensive care unit, complications associated with its installation and operation were practically not recorded.

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1.Optimal UVC position:

The tip of the catheter should be located in the inferior vena cava (ICV), at the level of the diaphragm and the vertebrae T8 and T9 [9], in everyday practice it should be considered the optimal position of the tip of the venous umbilical catheter in the inferior pudendal vein in the projection of the cavity into the right atrium [10], (Fig. 1,2,3).

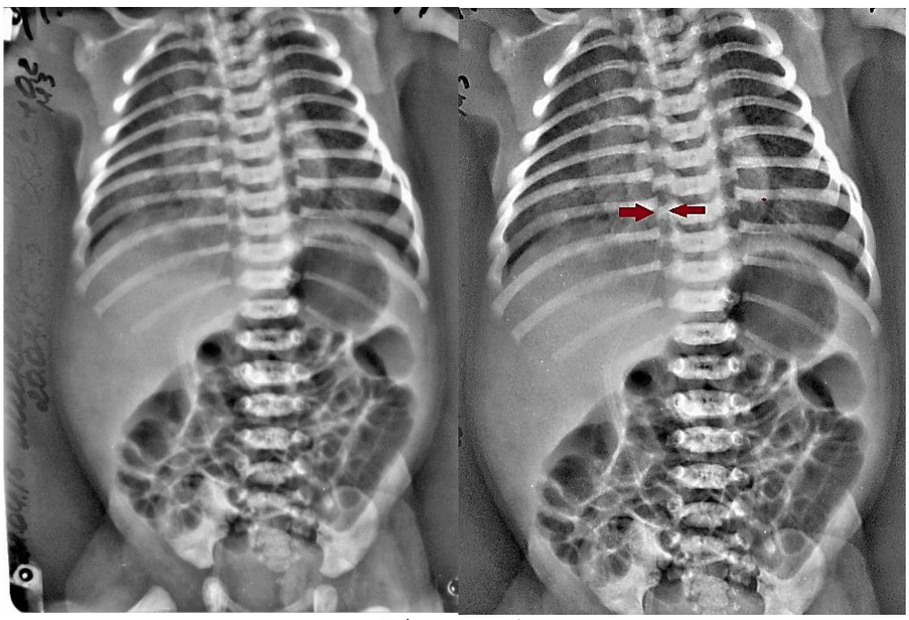

Figure 1

Newborn premature girl M., 30 weeks of gestation, 4 days old, intrauterine infection. The UVC tip is in the correct position at the Th8 aperture level

Allowable UVC position:

- at the level of the umbilical pocket (L1-Th12 centrally, without mixing with respect to the course below this level);
- in Ductus Venosus (Th12-10 centrally, without mixing with respect to the course below this level);
- in the left branch of the portal vein (turn horizontally to the right at the level of Th12 by 1 cm);
- in the portal vein (turn horizontally to the right at the level of Th12 by 1.5 cm with a downward bend of no more than 1 cm);

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- in the right branch of the portal vein (turn horizontally to the right at the level of Th12 by 1.5 cm).

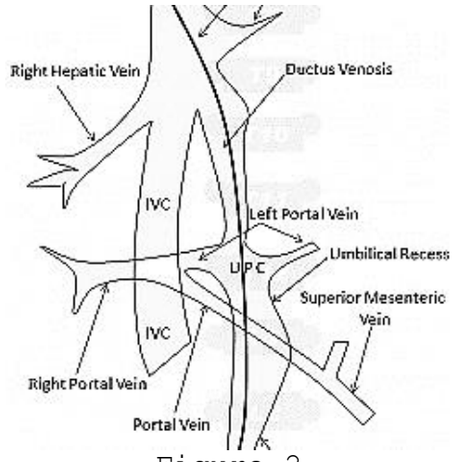

Figure 2

Skeletotopic diagram of the umbilical vein before it flows into the inferior vena cava (with junctions, in the region of the portal and hepatic veins [11]

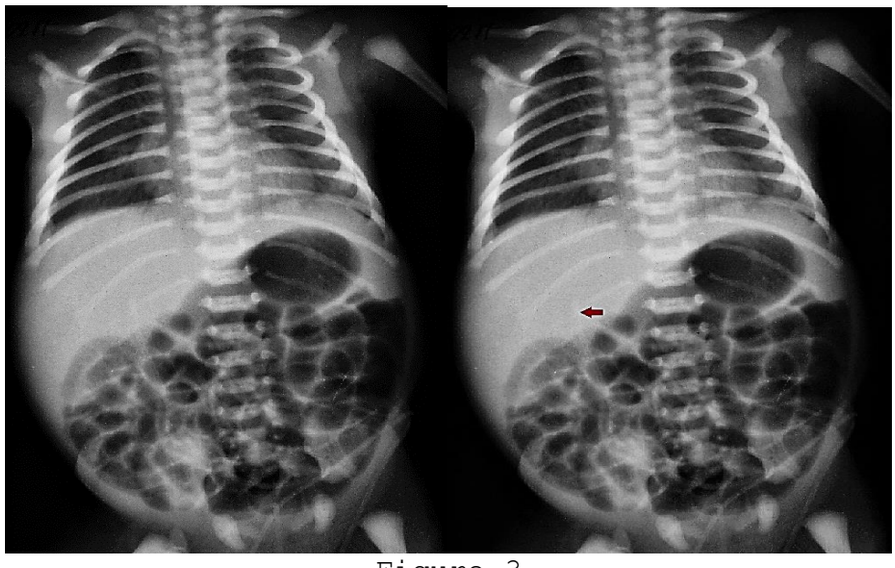

Figure 3

Newborn boy Ch., 2 days old. Respiratory Distress syndrome. UVC is located centrally at the level of Th12-10 in the projection of Ductus Venosus (red arrow) - the allowable position of the catheter. However, with this position of the catheter, high molecular weight solutions cannot be injected

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2. UVC misposition options:

1) Functional failure of UVC develops as a result of its superficial location (Fig. 4). A sign of the superficial location of the catheter is the central position of its tip below the L2 level, without deviation of the course (Fig. 4, 5A, 5B).

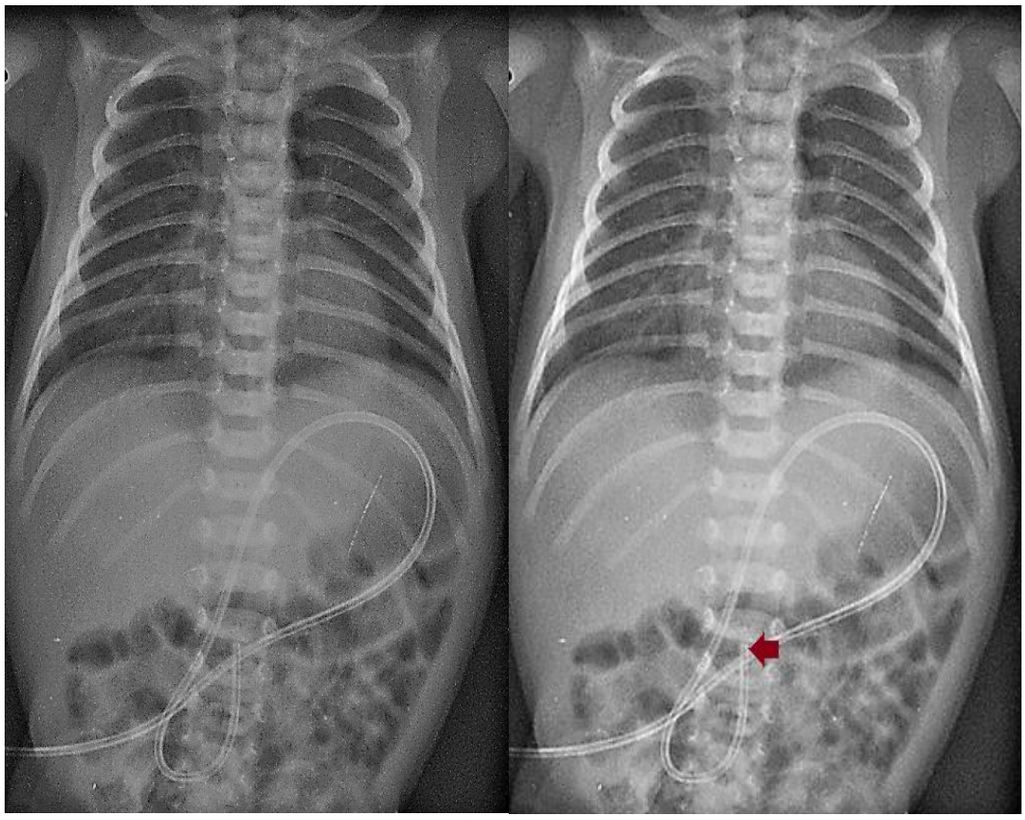

Figure 4

Newborn girl K., 4 days old. Superficial position in the umbilical vein. The tip of the catheter (red arrow) is located centrally at the level of L3. Delivery of drugs is difficult, the liver is enlarged in size, the shape is close to spherical

In case of clinical signs of functional failure of UVC without its radiographic manifestations (the catheter tip is above the L2 level, without deviation of the course), it is necessary to perform not only direct, but also lateral radiography of the abdominal organs (Fig. 5A and 5B).

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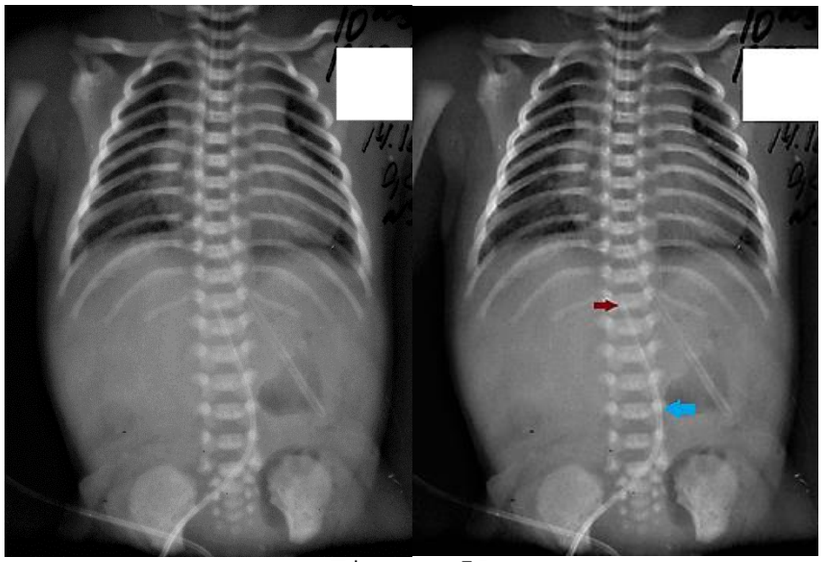

Figure 5A

Newborn O., 2 days old. Suspicion of superficial UVC. On a direct radiograph, the UVC tip is located at the level of Th12 (red arrow) in the projection of the umbilical pocket. However, its non-central position at the L2-L4 level outside the projection of the inferior vena cava, combined with clinical signs of UVC functional insufficiency, casts doubt on the correct position of the device

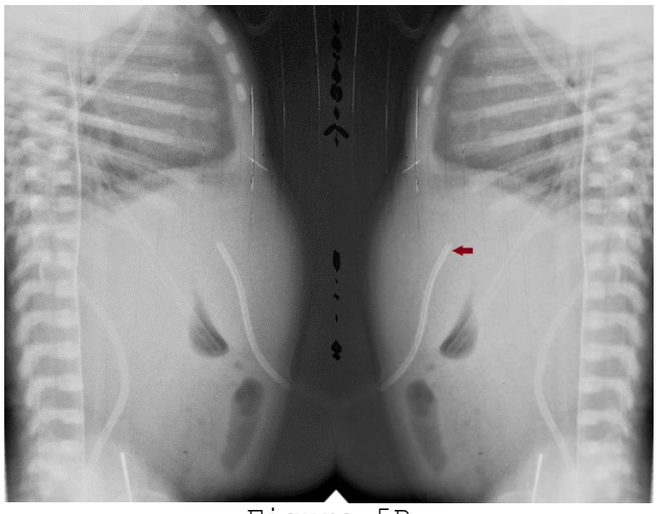

Figure 5B

Newborn O., 2 days old. Suspicion of superficial UVC. The lateral radiograph shows the superficial location of the UVC tip (red arrow). The nasogastric tube is located in the cavity of the stomach compressed by ascites, the position of the urinary catheter is routine

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2) Erroneous insertion of UVC into the umbilical artery instead of the umbilical vein (Figures 6A and 6B).

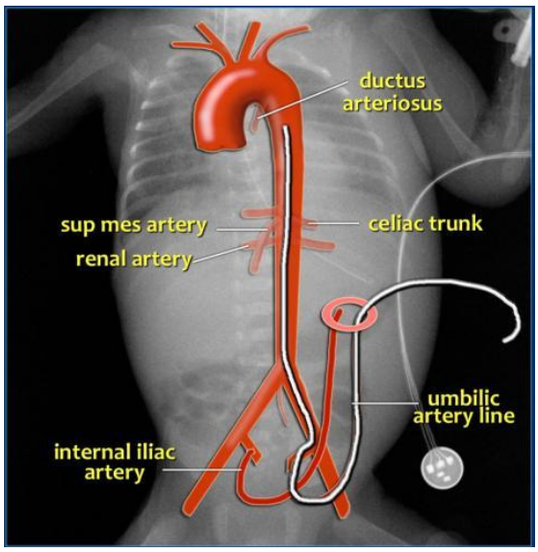

Figure 6A

Scheme of the correct position of the catheter in the umbilical artery with direct access to the arterial system [12]

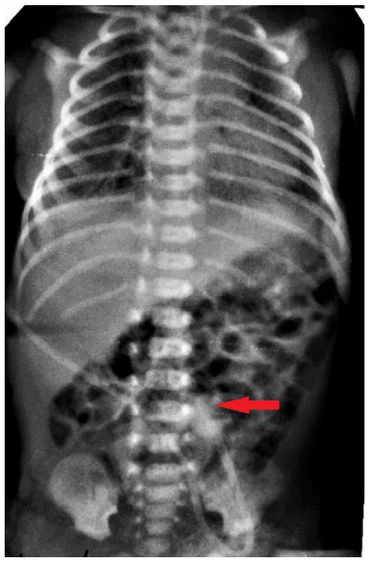

Figure 6B

Newborn Ch., 1 day old, UVC is located in the iliac artery at the level of L3-L4

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3) UVC must be extracted by visualizing its folds in the umbilical pocket (Figure 7).

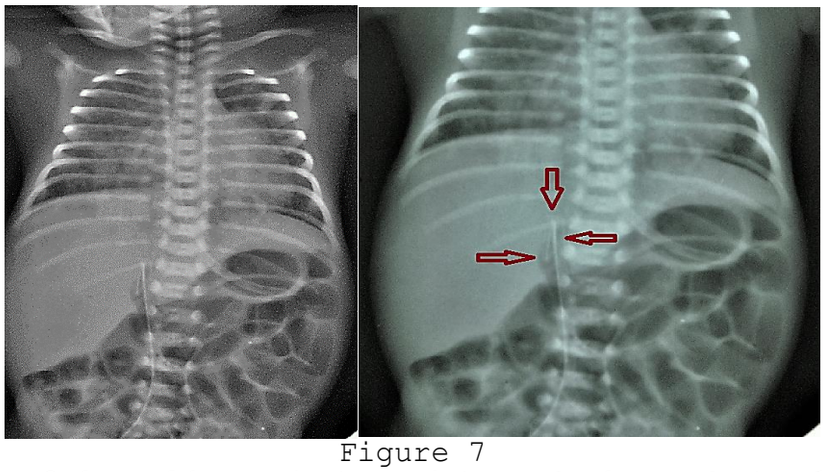

Figure 7

Newborn S., 2 days old. Respiratory Distress Syndom. UVC at TH12 makes a loop (red arrows). Not functioning. Must be removed due to risk of injury

4) With the position of UVC in the left portal vein, there is a real possibility of liver injury. A sign of such an erroneous position of the catheter is the horizontal turn of the catheter to the left at the level of Th12 for any length (Fig. 8, 9).

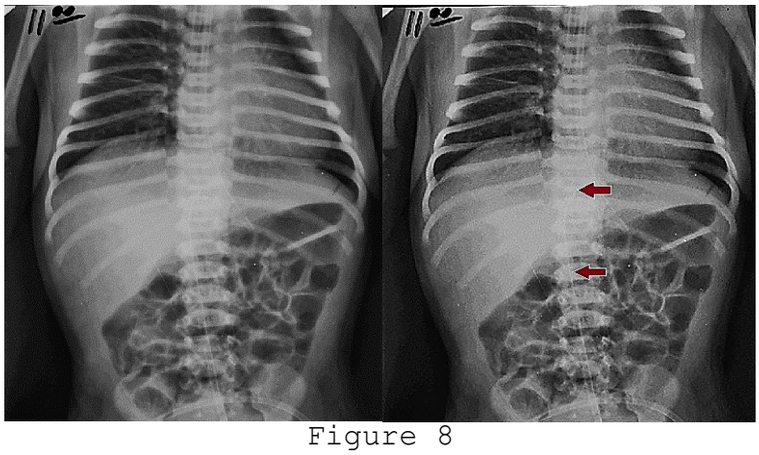

Figure 8

Newborn G., 2 days old. The nasogastric tube is located normally. Endotracheal tube - at the level of the bifurcation of the trachea. UVC (red arrows) is located at TH9. At the level of the umbilical pocket, UVC turns into the left portal vein

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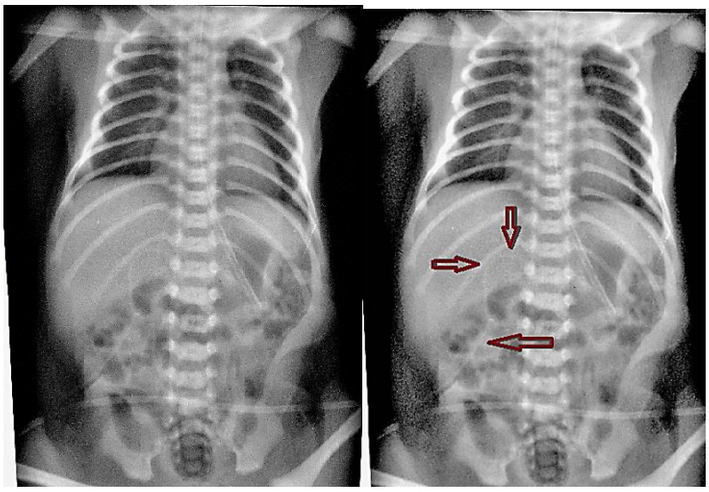

Figure 9

Newborn L., 2 days old. UVC at TH12 makes a horizontal turn to the left by 2 cm

5) When the catheter is in the right branch of the portal vein, liver injury is also possible. A sign of the incorrect position of the catheter is the visualization of its horizontal turn to the right at the level of Th12 with a length of more than 2 cm (Fig. 10.11)

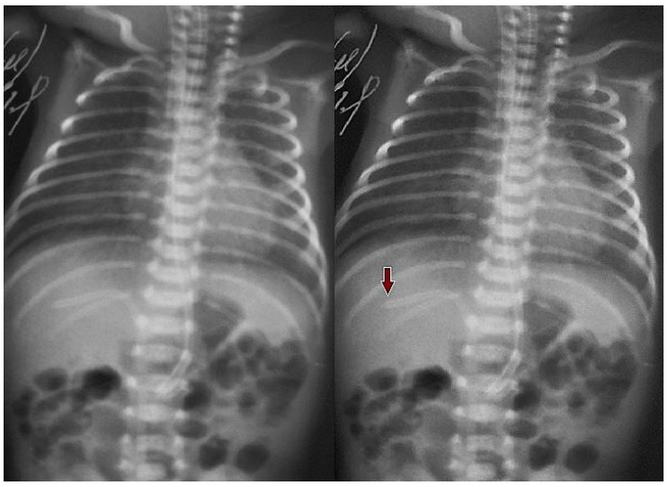

Figure 10

Newborn A., 2 days old. Endotracheal tube and nasogastric tube are located normally. UVC at TH12 makes a horizontal turn to the right by 2 cm (red arrow), located in the projection of the right portal vein

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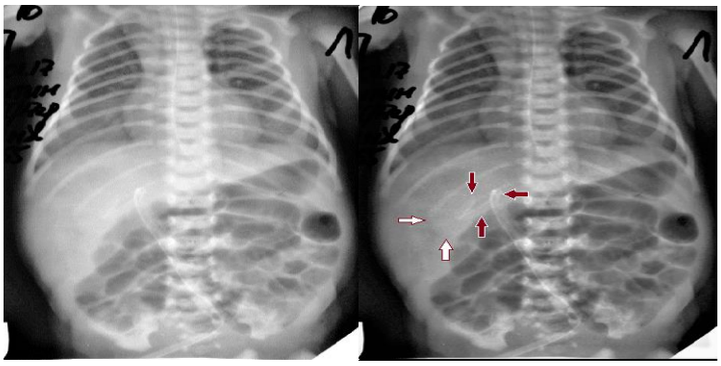

Figure 11

Newborn S., 2 days old. Respiratory syncytosis virus (SRV). The endotracheal tube and nasogastric tube are correctly positioned. Atelectasis of the upper lobe of the right lung. At TH12, UVC makes a 2 cm horizontal turn to the right with a second upward curve (red arrows). Near the tip of UVC, an area of increased density (white arrow) is determined, regarded as a hepatoma. The assumption was confirmed by ultrasound (not shown)

6) The presence of UVC in one of the hepatic veins can also injure the liver, a sign of which is the deviation of the device from the vertical stroke at the level of TN9-8 with a bend in any direction to any length. In this case, one should be aware of the likelihood of iatrogenic hepatoma (Fig. 12).

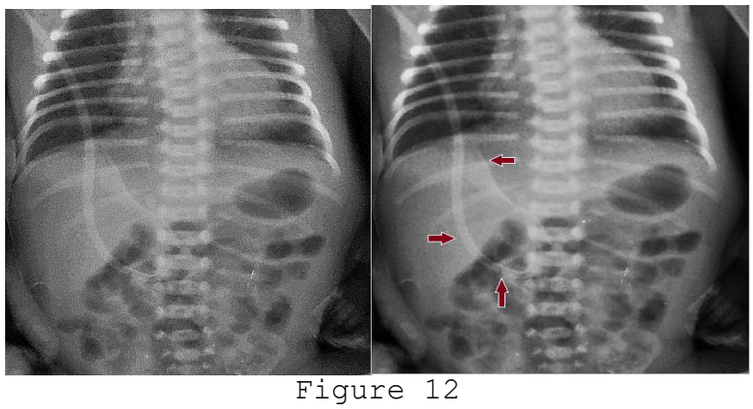

Figure 12

Newborn L., 3 days old. The course of UVC is marked with red arrows, at the level of Th12 it deviates to the right, the UVC tip is visualized up to the level of Th9 at the periphery of the liver. The area corresponding to the intrahepatic hematoma on ultrasound (not shown) corresponds to the area of increased density on the radiograph. Hepatic Vein injury

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7) When UVC is in the superior vena cava above Th5, trauma to the separation ridge is possible with subsequent bleeding and thrombus formation (or without them) (Fig. 13).

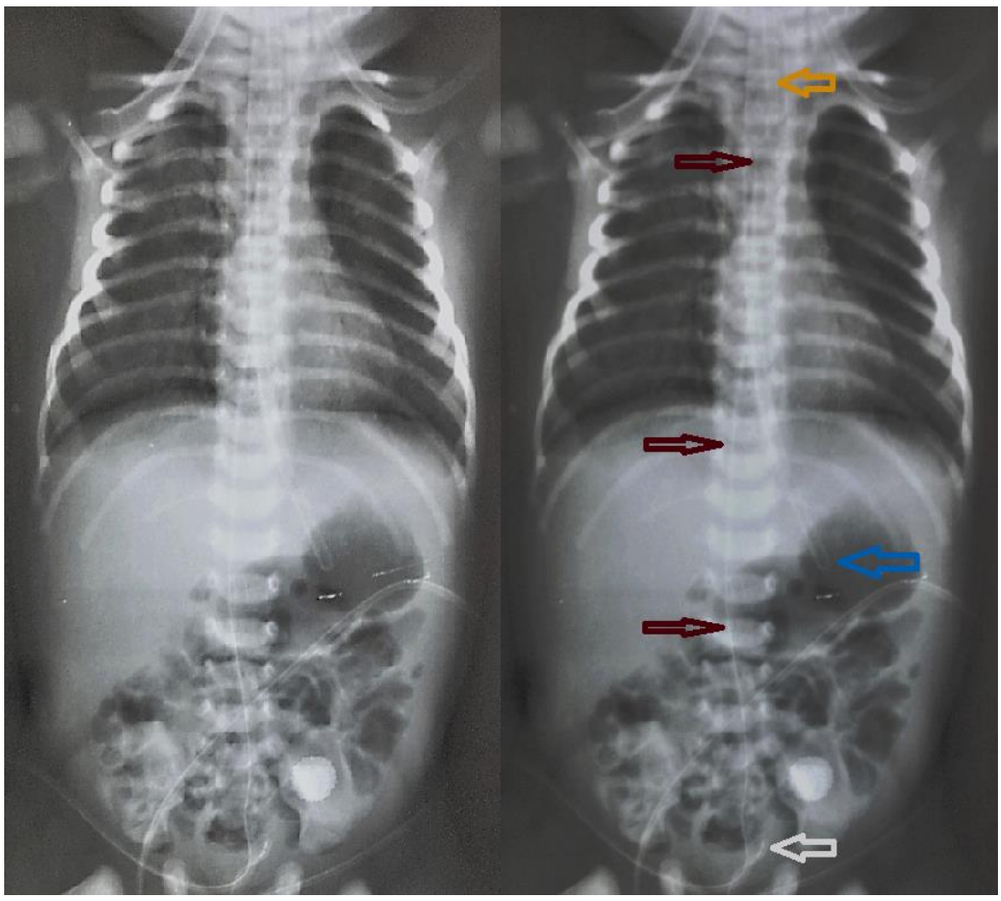

Figure 13

Newborn V., 1 day old. Endotracheal tube (yellow arrow) and nasogastric tube (blue arrow) and urinary catheter (white arrow) are located normally. UVC (red arrow) is located in the superior vena cava at TH3, where it entered through the inferior vena cava, bypassing the dividing ridge

8) When visualizing the UVC tip at the level of Th7-6 without deviating from the straightness of its course, it should be understood that the device is in the right atrium. In this position, thrombus formation begins for more than 4-6 hours. (Fig. 14)

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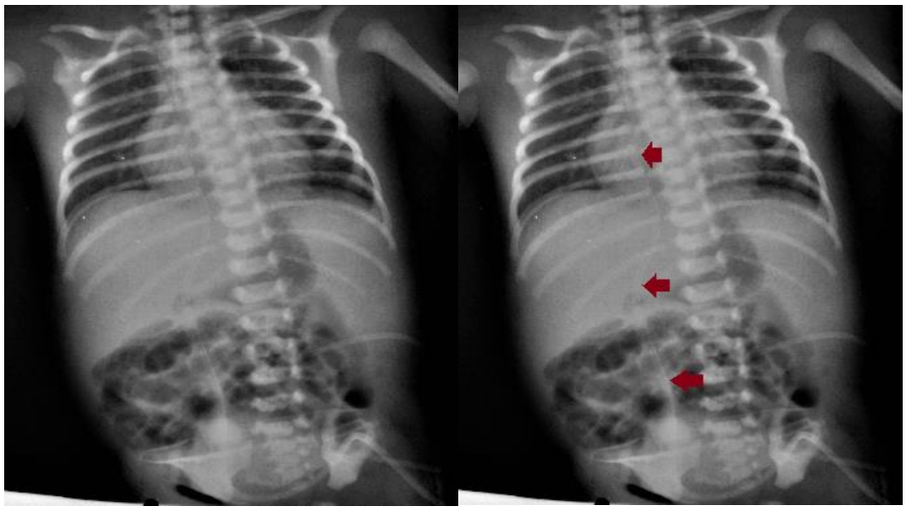

Figure 14

Newborn premature girl M. 32 weeks. gestation. 1 day old. Endotracheal tube is located adequately. Incomplete bowel rotation. Functional hyperpneumatosis. The UVC tip is located at the level of Th7 in the right atrial cavity (red arrows)

With a high central location of UVC at the level of Th 5-6, one should be wary of passing the catheter through the open foramen ovale into the left atrium. (Fig. 15)

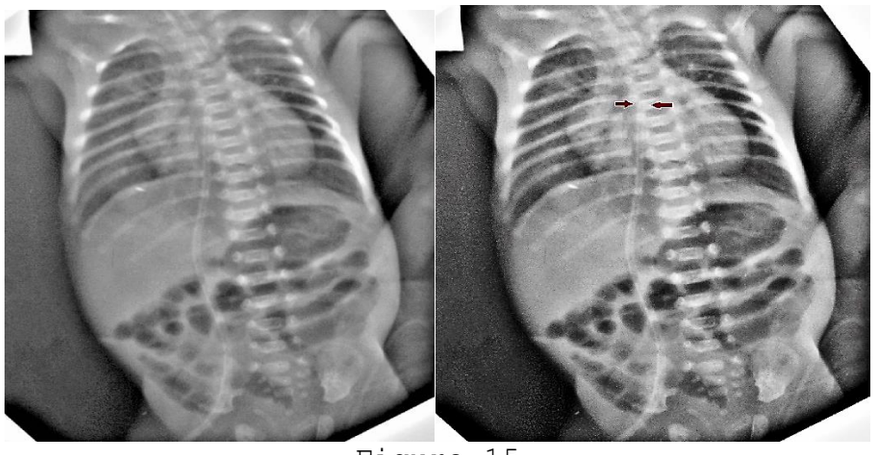

Figure 15

Premature newborn U., 2 days old, 28 weeks. gestation. The endotracheal tube is located superficially. Interstitial pulmonary edema. Functional hyperpneumatosis. The UVC tip is centrally located at Th5 (red arrows) in the right atrium in the foramen ovale projection

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9) The position in the left atrium is reliably diagnosed with the supradiaphragmatic position of the UVC tip at the level of Th 7-6 with a shift to the left by more than 2 cm. It should be understood that the catheter enters it through an open foramen ovale with intrauterine communications still open in some newborns. Such even a short exposure to UVC can cause the formation of a thrombus and complicate the condition of the newborn by migrating the formed thrombus through the pulmonary trunk to the lungs. A consequence of such a development of events may be PE. (Fig. 16)

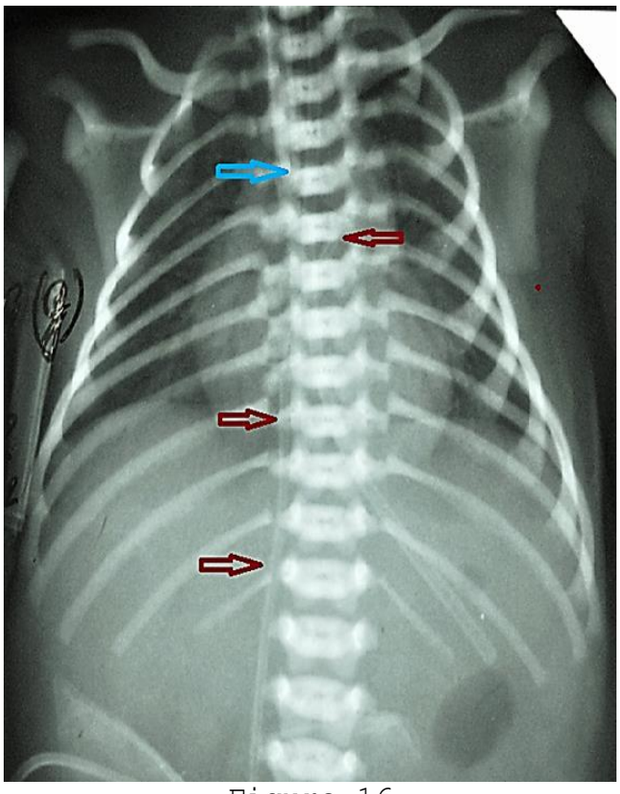

Figure 16

Newborn A., 1 day old. Endotracheal tube at TH4 (blue arrow). Nasogastric tube is usually located. The course of UVC is indicated by red arrows, its tip is located at the level of TH5 in the projection of the left atrium

10) The position of UVC in the pulmonary trunk can cause similar pathological processes. (Figure 17)

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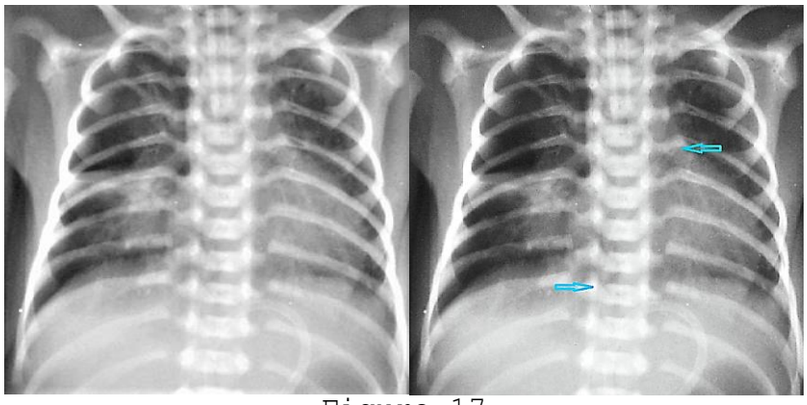

Figure 17

Newborn V., 2 days old. Endotracheal tube at the level of TH3. The right upper lobe of increased transparency, the pulmonary pattern in this section is not traced, the right root is "bare", the small interlobar fissure is pushed a little downward - a congenital cyst of the right upper lobe. The tip of UVC is visualized at the TH5 level in the projection of the pulmonary artery trunk (blue arrow)

11) The position of the device in the superior mesenteric vein may cause mesenteric vein thrombosis with or without thrombus migration. Such an erroneous location of the catheter is evidenced by its bend in the projection of the gate of the liver with a deviation to the L4 level. With all the elasticity of the device and its small size, the diameter of the corresponding vessel (superior mesenteric vein) is not able to function when UVC is in its cavity. Prerequisites for the development of a thrombus are created. (Fig. 18).

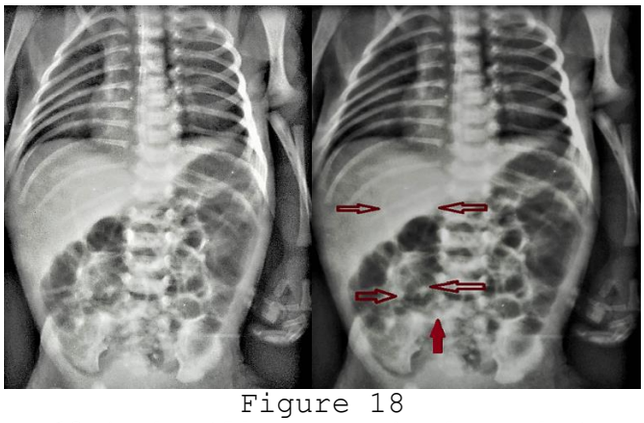

Figure 18

UVC loops at TH12 (red outline arrows), descends to L4 (solid red arrow): UVC is located at the confluence of the superior mesenteric vein with the portal vein

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12) One can think about the position of the catheter in the splenic vein if its tip is visualized in the projection of the hilum of the liver with a deviation to the L3 level, followed by a horizontal turn / bend by more than 2 cm. Complications are also associated with the likelihood of thrombosis.

13) The probability of the location of the inferior mesenteric vein in the UVC follows when the device is bent in the projection of the hilum of the liver, it deviates to the L3 level with a horizontal turn of up to 2 cm and deviates downward.

Conclusion

The UVC position largely determines the effectiveness of newborn management in the neonatal intensive care unit. Timely detection of an error in the location of the UVC and current monitoring of its position can reduce the number of complications to a minimum.

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