

POSSIBILITIES TO DIAGNOSE LIFE THREATENING CONGENITAL MALFORMATIONS

Daniela Iacob¹, RE Iacob^{1,2}

¹ „Victor Babes” University of Medicine and Pharmacy Timisoara, Romania

² County Emergency Hospital Arad - Dept. of Pediatric Surgery, Arad, Romania

Abstract

Genetic and malformative diseases are very diverse, appear at different ages and affect any system or organ. Major structural anomalies appear in 2-3% of live-born children and 2-3% are discovered in children up to 5 years old, summarizing 4-6%. Defects at birth are the main cause of infantile mortality, representing approximately 25% out of the total neonatal deaths. The main possibilities of paraclinical investigation to detect cardiovascular, digestive, renal-urinary and central nervous systems malformations during the postnatal period are presented hereinafter.

Key words: congenital malformations, diagnostic methods

Methods of Diagnosing Cardiovascular Malformations

Non-invasive methods of paraclinical diagnosis¹

1. Radiological examination – by cardio-pulmonary radiography the volume of the heart, the cardiomedastinal silhouette and the features of the pulmonary circulation may be appreciated.

Heart volume, as it appears on the radiological clichés (subjected to some error factors, such as exposure in expiration, association with a thymic hypertrophy etc) is still estimated by the means of cardio-thoracic index, accepted due to its simplicity (not to its fidelity). It is considered cardiomegaly the cardiac shadow that corresponds to a thoracic index of over 0.60 at the age of 1 month; over 0.55 at the age of 1 year and over 0.50 at 2 years of age. Cardiac insufficiency may be always considered associated to cardiomegaly in clinical practice¹.

A transversal oriented heart, with the top oriented towards left, suggests right ventricular hypertrophy, while the concavity of the middle left arch is a sign of hypoplasia of the pulmonary artery. The described aspect suggests a cardiac silhouette known as “coeur en sabot”, which is deemed classical in the tetralogy of Fallot. The prominence of the middle left arch suggests post-stenotic dilation, characteristic to the pulmonary stenosis. Pulmonary hyper-vascularisation is typical in the left to right shunts. It is also characteristic to malformations with the reduction of the pulmonary blood debit (stenosis, pulmonary hypoplasia, and pulmonary valves atresia). This is radiologically expressed through an increase in pulmonary transparency. The aspect is associated with some cyanogens congenital diseases without any possibility to demonstrate a direct relation between pulmonary hypo-vascularisation and cyanosis (tetralogy of Fallot). The transposition of the large blood vessels and the common arterial trunk are cyanogens

congenital diseases in which pulmonary hyper-debit is present.

2. The electrocardiography is one of the classical methods to assess the congenital heart malformations. Interpretation is strictly dependent on the patient's age, although the significance of the waves on the route is the same, meaning: where P corresponds to the electrical activity of the atriums, QRS wave corresponds to ventricular depolarisation and T wave to ventricular repolarisation (having the same route as R wave). The heart rate of 130-150 beats/min in newborns progressively diminishes towards puberty. The newborn has right ventricular predominance (a consequence of foetal hemodynamics), while the teenager has left ventricular predominance. In this context the notion of ventricular hypertrophy, right or left, becomes pathological according to age. The affirmation of ventricular hypertrophy on ECG suggests an electrical syndrome and not an anatomical aspect. No ECG modification is patognomonical for a certain congenital malformation; therefore this exam is an adjuvant in establishing the diagnosis of congenital heart disease, its value being unaltered in both rhythm and conduction disorders¹.

3. Echocardiography

The ultrasonography with application in cardiology is the real technical revolution of the last decade, bringing to the top the diagnostic value of non-invasive techniques.

One-dimensional echocardiography studies the heart in one dimension. This technique practically measures, in different moments of the cardiac cycle, the dimensions of the heart cavities, the width of the cardiac walls and of the intra-ventricular septum, as well as the kinetics of the valves.

Bidimensional echocardiography (2D) studies the heart from two perspectives; there are standardised planes through different exploration paths: left parasternal, apical, subcostally, suprasternally. The purpose of the many planes that exist is to specify the anatomy of heart and vessels. Moreover, it is possible to qualitatively study the contraction function of the ventricles^{2,3}.

Doppler echocardiography is a useful complement of imagistics. It is based on the physics principle described by C.H. Doppler in 1842, which refers to the interaction of a sound wave when meeting a moving object. The ultrasound emitted by the transducer, which meets a blood current, are in part reflected by its most mobile structures (moving hemarties). The echo reflected by these is different from the echo of the ultrasound fascicle. This frequency difference is

the Doppler signal. The reflected sound is heard and is, at the same time, graphically recorded, its qualities being analysed by a computer, with the auditive recording being the qualitative component and the visual recording the quantitative one. Doppler echocardiography allows for the detection of intracardiac blood flows, measures their speed and, indirectly, pressure gradients. There are two types of Doppler echocardiographies².

a) Continuous wave Doppler: a piezoelectric crystal emits a continuous ultrasound signal. This signal is reflected by the figurative blood elements, especially red cells, towards a crystal receptor. As the blood flow comes closer to the sound receiver, the reception frequency is higher than the emission frequency. The frequency difference is more important as the flow is more rapid. Continuous Doppler allows the measurement of the blood speed, even if it is very fast. But it has the inconvenient that it does not allow a precise spatial localisation of the flow, as it studies the speed over the entire ultrasound fascicle.

b) Pulsed wave Doppler uses a succession of ultrasound emissions, interrupted by pauses, while the emission crystal acts as a receptor of the reflected echoes. The returning time of reflected echoes allows estimating the distance to the explored area, as the speed of ultrasounds into tissues is known. Pulsed wave Doppler together with a bidimensional echocardiogram allows precise space localization.

Colour coded Doppler is a variant of pulsed wave Doppler. Digital analysis and colour codification allows for a coloured bidimensional representation of the blood flow. Colours vary according to direction, speed and the laminar or turbulent character of the flow. The colours were arbitrarily used by the builder of this equipment: the red colour indicated a blood stream heading towards the transducer, while the blue colour indicated a blood stream moving away from the transducer. Colour Doppler allows identifying rapidly the normal and pathological flows and also detecting anomalies that may be missed during a bidimensional analysis.

Myocardial function may be studied by the means of echographic methods: the contraction function of the left ventricle (systolic function) and the filling function (diastolic function). For the contraction function of the left ventricle the one-dimensional echocardiography is used to measure the four parameters: shortening fraction, systolic contraction index, average speed of fibre shortening and ejection fraction of the left ventricle; in all the severe disorders of the myocardial function, such as myocarditis, these indicators are abnormal¹.

Three-dimensional echocardiography brings new details to the non-invasive heart investigation.

4. Magnetic resonance imaging (MRI) and computer tomography (CT), a technological burst of the last decade, brought remarkable progress in evaluating the cardiac child. It has the advantage that it does not use the ionising radiation and it can offer images in three plans, but the examination cost is very high (double unto the one of a computer tomography examination)^{4,5,6}.

The adverse biological effect of the high intensity magnetic field (in which the patient is placed during the examination) has not been sufficiently documented. The patient's sedation is mandatory for patients under 7 years of age and the investigation cost limits its extensive usage.

MRI brings valuable information in evaluating the anatomical details of the heart and mediastinum, when the data obtained through bidimensional echography are not considered optimal. The diseases of the aorta (coarctation and supravalvular aortic stenosis), anomalies of the pulmonary arteries, including the obstructive pulmonary vascular disease, the abnormal venous return and the complex congenital cardiopathies are cited as indications for this exam.

5. Radioisotopic exploration

The principle of this method consists of the intravenous injection of a very concentrated radioactive embolus (vol. under 0.5 mm³) which reaches the cavities of the heart, the pulmonary blood system and the great vessels at the basis of the heart. The radiotracer is then detected following the emitted gamma radiations, using a gamma camera.

Isotopic exploration is a non-invasive diagnosis method, which produces data comparable to the ones obtained through cardiac catheterism. It is indicated for obtaining data referring to the pulmonary and myocardial blood flow, myocardial perfusion, lung perfusion and detection of cardiac shunts.

Invasive methods of paraclinical diagnosis

Cardiac catheterism and angiography are invasive diagnosis techniques that bring very exact anatomic and hemodynamic information. They are still the most precise and reliable methods for measuring pressure, debit and resistance. The method is superior to the 2D echocardiography as regards the spatial perspective and less dependent on the human factor. These are indicated especially in the situations in which echocardiography fails: appreciating the extracardiac elements, abnormal pulmonary or systemic venous return, anatomy of the aortic arch, pulmonary trunk and pulmonary artery branches, as well as in the evaluation of intracardiac elements (interventricular septum, the ejection way of the right ventricle). Cardiac catheterism may become therapeutic, perforating the interatrial septum in the transposition of great vessels or efficiently dilating the pulmonary and aortic valvular stenosis. It is currently attempted the dilation of the stenosis of the branches of pulmonary arteries.

The stenosis or valvular regurgitation degree can be accurately determined. A right catheterisation (femoral vein) is usually used and more rarely a left one (arterial retrograde manner, Sedinger technique).

Cardiac catheterism remains an exact technique for appreciating the shunts, evaluating the oximetry and intracavitory pressure, appreciating the pressure gradients between the two parts of the stenotic lesion, measuring the systemic or pulmonary flow, as well as the pulmonary vascular resistance.

Cardiac catheterism can be completed by endomyocardial biopsy, using an adequate bioptome. Histological evaluation is allowed in dilative or hypertrophic cardiomyopathy, endocardial fibroelastosis, myocarditis or cardiomyopathy after chemotherapy (Adriamicina).

Using modern methods and equipment, doctors may use digital subtractions angiography, which allows the use of small quantities of contrast substance (20-60% out of the conventional dose) and a smaller dose of radiation (10%). It is because of these advantages that this method is widely used in paediatrics¹.

Diagnosis methods in digestive tube malformations

The last two decades have unexpectedly diversified the possibilities of invasive and non-invasive exploration of the digestive tube, starting with the new-born period. Accurate diagnosis of anomalies and lesions have been imposed by the extraordinary growth of paediatric surgery, which, by improving its intervention techniques and resuscitation methods, successfully approaches the medical care of very young children, new-borns and even foetuses. Without using paraclinical exploration methods, the digestive tube is less accessible to the direct clinical exam^{1,7}.

1. Radiological exam is still used, from the first day of birth, with or without a contrast substance. We have to remind the fact that the new-born needs to be immobilized using special techniques, in order to avoid the irradiation of the medical staff and the patient. The radiographic exam can be used to bring useful information in congenital duodenal stenosis, meconial ileus etc.

2. Radiological exam with contrast substance completes the information obtained. The baritare solution is more physiological than the iodate contrast substances, which, being hypertonic can cause dehydration in young patients. This solution is easy to administer and ensures a good resolution, if there are no deglutition disorders or aerodigestive fistulas and if it reaches the lungs. It can be administered through a gavage tube or by bottle feeding. Except for the esotracheal fistulas and the deglutition coordination disorders by cricopharyngeal achalasia, the administration of the contrast substance by catheterising the esophagus brings valuable information in all obstructive lesions of the digestive tube in new-borns, such as hypertrophic pyloric stenosis, duodenal stenosis, intestinal stenosis, rotation vices etc.

3. Percutaneous hepatic biopsy, performed with a needle, is still considered an adequate evaluation method for some hepatic lesions, which evolve at pediatric age. Investigating the haemostasis before this procedure is compulsory. It is preferable to be performed in the morning, on an empty stomach, and to be followed by an active period of supervising the patient and the potential complications. It is mandatory to sedate the child and even general anesthesia is required in case of an extremely anxious or uncooperative child. The optimal diameter of the needle is 1.2 – 1.4 mm. The major indications of hepatic biopsy are: extrahepatic biliary atresia, congenital hepatic fibrosis.

The contraindications for hepatic biopsy are: uncooperative child (unless we use general anesthesia), coagulation disorders (frequently associated with hepatic diseases), local infections (cholangitis), ascites, severe obstruction of extrahepatic biliary ducts and severe anemia. Complications are associated with the patient's state, lack of adequate instruments and the professionalism of the doctor executing the manoeuvre. Morbidity is 5% in the case of this procedure and the mortality reported in the literature is 0.15-0.17%.

Echographic exploration of the upper abdomen is currently used in our country too, being the first option for many paediatricians as it is completely un-aggressive and largely indicated. Its main advantage resides in the absence of any unpleasant consequences for the child, the possibility to repeat the exam in order to control the evolution of the lesions, no counter-indications and no preparation of the patient, good resolution of the images, especially in the case of parenchymal organs (liver, pancreas, spleen).

4. Computed tomography (CT) is the method that uses X rays for exploration, which allows the transversal sectioning of the body. The obtained images are in tones of grey, according to each tissue's density. Water is considered to have zero density, while air and fat have negative values. All abdominal viscera have different values, greater than zero. There is indeed a juxtaposition of different densities of abdominal parenchymal organs (for example pancreas is sometimes hard to distinguish from the duodena using only the density criteria). The small dimensions of the adipose pancreaticum in children make it more difficult to clearly delimitate between the different intra-abdominal organs.

The list of CT indications in children's digestive pathology is continuously diversifying, but the palpable abdominal masses, the appearance of which could not be established echographically, become the first diagnostic choice. The method must be recommended restrictively in very young children in whom the resonance of the abdominal images is unclear, because of the lack of the adipose pancreaticum. The doctor will take into account the high degree of X-ray irradiation and also the movement problems that require good cooperation with the child and, if necessary, his sedation.

6. The sweat test is a reliable, specific test, positive in 99% of the cases for pancreatic cystic fibrosis. The quantitative determination of the electrolyte concentration of the sweat has as a starting point the stimulation of the sweat through different procedures and the quantities of EC and Na⁺ are determined in harvested sweat and expressed in mEq/l.

Diagnostic methods in malformations of the urinary apparatus

1. Excretory urography has as main principle the kidney's excretion of an injected radio-opaque substance and brings information about the urinary apparatus, but also functional data (the time passed between the injection of the substance and the excretory urogram) as the excretion of the substance depends on the serum level, on the kidney's

concentration capacity (it is not a valid exam for a newborn, who has a reduced capacity of urine concentration) and the glomerular filtration. Normally the secretion of the contrast substance begins immediately, attains its highest point at 10-20 minutes and is much slower in renal insufficiency. The renal radio-opacity increases, because the contrast substance is concentrated in the renal tubes. The best nephrogram is obtained in the first minute and allows the evaluation of the dimensions, form and place of the kidney. It is also very dense in urethral obstructions.

2. Mictional cistography or mictional cistourethrography is practiced to evaluate the lower urinary tract functionality. The urethra is catheterised (attention in boys) and, with the catheter placed in the urinary bladder, the contrast substance diluted with physiologic serum is injected. The introduced volume varies according to the age (30 ml for a newborn, 100-200 ml for a child). A static cistogram is obtained, another one during miction and a last image afterwards, for assessing the urinary residues or the reflux at the end of miction.

3. The ultrasonography is largely used to acquire statistical data regarding the situation, the morphology and the dimensions of the kidneys, or as a guide for a renal biopsy puncture. In ultrasonographic images the kidneys have an elliptical shape, neither the calyx and pelvis, nor the normal ureters being identified. Suprarenal glands are difficult to be identified echographically, but the pyelocaliceal calculi and the renal cysts can be distinguished¹.

4. Computed tomography (CT) is essential for appreciating the dimensions of the renal tumours, their reactions with the proximal organs, the situation of the retroperitoneal space, invasion of the cava vein, hematomas or the renal or peritoneal abscesses. The method used for psoas hematoma is highly valuable.

In assessing the abdominal masses suspected to be of renal origins, all the presented methods will be used for a diagnosis. An exact diagnosis can be obtained, but the sequence in which they are used varies according to the experience of each medical team. Some use the urography as first method to obtain data, the echography and CT being used to obtain complementary information. Other medical teams use the echography as a routine diagnostic method, using the other two afterwards. If surgery is needed, CT must precede it.

5. Nuclear medicine uses radioactive isotopes to establish a diagnosis. Two methods are used for diagnosing renal diseases: isotopic nephrogram and renal scintigram.

Methods of paraclinical exploration of CNS

There is no other field of pediatrics in which modern investigations have changed so dramatically the diagnosis possibilities as the field of CNS pathology. New methods, that could not even have been imagined two decades ago, are used in daily medical practice, so that we have exact, non-invasive diagnostic methods that require sophisticated and extremely expensive medical equipment, with no

procedure risks, as it is the case when using the classical methods^{1,8}.

1. The simple radiography is useful in diagnosing cranium bifidum, spina bifida occulta, cranial dermal sinuses, spinal dermal sinuses, diastematomyelia, syringomyelia, Arnold-Chiari and Dandy-Walker malformations, craniostenosis, and hydrocephaly.

In meningoencephalocele, a simple Rx of the skull reveals the place and the dimension of the bone defect. The defect is well delimited, with clear regular margins, of variable length, but there is no proportional ratio between the dimension of the meningoencephalocele and the bone defect. The bone defect has a round shape; the defects situated basally, profoundly, have an oval shape and are observed through CT. Partial absence of the posterior arch with the enlargement of the vertebral canal on several segments on an Rx leads to a meningoencephalocele /meningomyelocele diagnosis.

The simple radiography and with contrast substance is extremely useful in diastematomyelia. The simple Rx of the thoracolumbar spine distinguishes the centre of the spinal canal, disposed in the area of spina bifida, extended on one or more segments. The spinal canal appears dilated, with the maximum length at the level of the bone spur. This dilation is not associated with changes of the pedicles and vertebral erosions, which differentiates it from the dilations given by intraspinal expansive processes.

In diagnosing the Arnold-Chiari malformation the simple and contrast Rx are extremely useful. A simple exam can show signs of hydrocephaly and a possible anomaly of the crano-rachidial region (basilar impression, occipitalisation of the atlas, cervical rib) or the lumbar-sacral region.

Inconsistent deformations of the skull are seen in Dandy-Walker malformation. These are represented by the growth of the antero-posterior diameter and the prominence of the occipital region in the middle of the posterior fosse, disjunctions of sutures, opening of fontanelles.

In congenital hydrocephaly Rx distinguishes a skull with the aspect of a balloon, with round contours, an exaggerated disproportion between the size of the skull and the facial massive, with a big anterior fontanel. The transparency of the skull is increased with a thin skull and no bone structure. The margins disappear and the sutures are invisible, the skull appearing as a big ball with fine limits, in which there is an opalescent uniform aspect. Sometimes there is a "lacuna skull", more visible in the parietal regions. If the sutures appear or become more obvious than at an anterior radiography, that is a proof the hydrocephaly is stabilizing and, after simple radiological exams, an etiological diagnosis of hydrocephaly is set.

The radiological diagnosis of skull lacunas in children is important, as it is associated with other malformations (spina bifida, cleft palate, anomalies of ribs and extremities). The radiological diagnosis of skull lacunas in children is easy in typical forms, congenital skull lacunas being more difficult to diagnose in atypical forms, with all the possible skull lacunas in children (traumatic, tumoral, and generated by systemic maladies). Islands of

demineralization can be observed on radiological images. These transparent islands, having different dimensions, rectangular, contoured, and placed side by side, are separated by narrow septa of dense bone, anastomosed. The images should show especially the parietal bone and are situated bilaterally, but not symmetrically. A bone hierarchy is not respected. The bone lamellae are anarchically disposed and the lacunas portions are poorly vascularised.

The radiological exam is very important in diagnosing the skull stenosis and establishing the exact type.

From a radiological point of view, we can observe:

- anomalies of sutures, one or more being absent;
- disappearance of the teethered aspect of the suture in children;
- persistence of some sutures in the form of linear ligaments;
- existence of bone bridges on a suture's line;
- marginal densifications at suture level, showing excessive osteogenesis (important presumption sign).

2. Pneumoencephalography is a useful investigation for diagnosing congenital malformations of CNS. In meningoencephalocele it shows the cerebral-ventricular participation to the malformation, important element for surgery.

In the case of agenesis of pellucid septum, diagnosis can be made only based on pneumoencephalography, which brings out the lateral ventricles, forming one cavity. It can also show a concomitant internal hydrocephaly due to the cortical atrophy. Corpus callosum agenesis shows a typical butterfly shaped ventricular aspect. It allows the appreciation of the liquid ways for defining the obstruction level and for guiding the neurosurgeon in executing some interventions.

3. Ventriculography – in Arnold-Chiari malformation shows the status of the cavities (ventricles III and IV, aqueduct of Sylvius), the complete or incomplete blockage and the associated nervous anomalies (volume growth of the inter-hemispheric grey commissure, total or partial absence of septum lucidum).

The dilation of the IV ventricle which occupies the posterior fossa is present in Dandy/Walker malformation. In corpus callosum agenesis may be seen:

- dilation of III ventricle and the dorsal extension between the lateral ventricles;
- increase of the distance between the lateral ventricles;
- dilation of the posterior horns of the lateral ventricles;
- angulation of the dorsal margins of the lateral ventricles;
- concave medial margins of the lateral ventricles.

Ventriculography can show the obstruction of the Mauro hole, the lack of communication between the lateral ventricles and with III ventricle, hydrocephaly and a defect of filling the anterior side of III ventricle. It can be used in the diagnosis of arachnoid cysts and hydrocephaly.

4. Transillumination can reveal, in meningoencephalocele, the transparency of the formation, but it can not show whether cerebral participation is present

or not. It can be useful to reveal the liquid accumulation in meningoencephalocele. It highlights the hyper-transparency in hydrocephaly only when the brain mass is reduced to 1-2 cm, therefore in advanced hydrocephalies.

5. CRL exam, obtained by the means of ventricular or lumbar puncture, is useful in the case of hydrocephaly. A small quantity of liquid, 2-5 ml is taken, not to produce a sudden decompression. Two aspects are envisaged: inflammatory dosage, tumoral and hemorrhagic.

6. Vertebral angiography is used in Arnold-Chiari malformation; by injecting the posterior-inferior cerebral artery, which forms a concave loop round the herniated cerebellar amygdala, aspect described as "coop sing".

In Dandy – Walker malformation it highlights the rise of some arteries (posterior cerebral and cerebellar).

Carotid angiography, characteristic in corpus callosum agenesis, shows the absence of the bend of the anterior cerebral artery. It is used in diagnosing arachnoid cysts and basilar impression.

A prognosis can be made in hydrocephaly by the means of angiography. The aspect of the arteries and veins indicates if surgery is possible. A differential diagnosis can be made between severe hydrocephaly and hydronephrosis, tumours, subdural masses, vascular malformations.

7. Myelography with pantopaque and gas contrast is used in the case of meningoencephalocele, and with lipiodol in diastematomyelia.

The opaque iodine substance is separated in two columns that surround the median line spur, accurately visualizing the level and extension of the malformation. In syringomyelia the gas myelography is used, which can show a total or partial blockage or the association of Arnold-Chiari malformation. Myelography can be also used in diagnosing Arnold-Chiari malformation.

8. Cerebral scintigraphy is used in fistulised, endonasal, basal meningoencephalocele. In order to diagnose fistula, the scintigraphy with radioactive iodine-labelled serum albumin (RISA) is recommended.

It is used in the hydrocephaly of the newborn for the study of the ventricular and cisternal spaces and the circulation of CRL. Human iodated serum albumin, RIHSA or Te, may be used in the case of hydrocephaly. RIHSA albumin is used in studies requiring an observation of 48-72 h and Te albumin is used for detailed exams that last up to 18 h. This investigation is very important to assess the factors responsible for hydrocephaly, providing important data for improving the ways, circulation speed and CRL absorption.

9. Computer tomography is of great importance for the diagnosis of basal encephalocele. It is also used in diagnosing Dandy-Walker malformation and the basilar impression.

10. Electroencephalogram (EEG)

There is no characteristic route in hydrocephaly. In the case of craniostenosis, the frequency of EEG disorders depends on the evolution stage and age. EEG shows bioelectrical anomalies, diffuse in all derivations of the both hemispheres as a result of brain compression. The anomalies recorded on the EEG route are slow Theta waves and even slow Delta waves. The presence of synchronous and

bilateral ample slow wave discharges on the EEG route also indicates an implication of the profound subcortical formations in craniostenosis. The larger the craniostenosis is, the more serious EEG anomalies are.

11. Ecoencephalography may provide indications in hydrocephaly and not only, about the dimensions of the ventricles and the thickness of the cerebral mantle.

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Correspondence to:

Daniela Iacob
Transilvania Street,
No. 13, Sc. C, Ap. 7,
Timisoara 300143,
Romania
E-mail: danielariacob@yahoo.com