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ORIGINAL ARTICLE

THE ULTRASOUND DIAGNOSTICS POTENTIAL OF THE SMALL PELVIS TUMORS IN CHILDREN

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ABSTRACT

Purpose of the study. To assess the potential of sonography in the diagnosis of pelvic tumors in children.
Patients and methods. We retrospectively analyzed results of ultrasound examination of the small pelvis, abdominal cavity and retroperitoneal space in 110 children with pelvic cancer referred for examination and treatment to National Medical Research Centre for Oncology of the Ministry of Health of Russia, distinguishing the most significant ultrasound parameters regardless of the tumor histological structure. 69.1% of patients were diagnosed with germ cell tumors, including 72.4% with gonadal and 27.6% with extragonadal tumors, 85.8% with sacrococcygeal tumors, 9.5% — uterine and 4.7% — vaginal tumors. Rhabdomyosarcoma was detected in 25.4%, neuroblastoma in 4.5% and a primitive neuroectodermal tumor in 1%. Standard ultrasound examination was performed using scanners Philips IU22 (USA) and Logic 400 MD (GE, USA) with convex transducers (3.5–5.5 MHz) in grayscale, color Doppler and power Doppler modes.
Results. The first stage of diagnostics showed that malignant pelvic tumors were characterized with an irregular shape registered in 97 (88.2%; $p<0.0001$), uneven, fuzzy contours — 94 (85.5%; $p<0.0001$), heterogeneous echostructure — 102 (92.7%; $p<0.0001$), in 70 people (63.6%; $p=0.001$) due to cystic inclusions, calcified inclusions were found in 37 (33.6%; $p>0.05$); tumor echodensity was reduced in 75 children (68.2%; $p=0.001$). Dopplerography in most patients — 100 (90.9%) — registered a hyperintense intratumoral blood flow, mainly of an arterial type, with maximum arterial velocities (MAV) ranging from 12.5 to 45 cm/s, average MAV = 30±2.7 cm/s. The specificity of the method was 86.3% ($p=0.001$), sensitivity 85.2% ($p=0.011$), accuracy 87.5% ($p=0.014$). Ultrasound monitoring was performed during treatment after each polychemotherapy cycle; we assessed changes in the size of tumors, their structure and neovascularization, allowing evaluation of the antitumor treatment effectiveness.
Conclusion. A complex sonography is an important method in the primary diagnostics of pelvic tumors in children, as well as a priority method in antitumor treatment monitoring, which allows detection of the tumor extent and helps to avoid multiple radiation exposure of the growing child's body.

Keywords:
pelvic tumors, children, germ cell tumors, neuroblastoma, rhabdomyosarcoma, ultrasound examination

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ОРИГИНАЛЬНАЯ СТАТЬЯ

ВОЗМОЖНОСТИ УЛЬТРАЗВУКОВОЙ ДИАГНОСТИКИ ОПУХОЛЕЙ МАЛОГО ТАЗА У ДЕТЕЙ

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РЕЗЮМЕ

Цель исследования. Оценить возможность сонографии в диагностике опухолей малого таза у детей.
Пациенты и методы. Нами были ретроспективно проанализированы протоколы ультразвуковых исследований малого таза, брюшной полости и забрюшинного пространства 110 детей со злокачественными опухолями полости таза, проходивших обследование и лечение в ФГБУ «НМИЦ онкологии» Минздрава России, с выделением наиболее значимых ультразвуковых параметров независимо от гистологической структуры. Выявлено 69,1% человек с герминогенными опухолями, среди которых 72,4% пациентов с гонадной формой и 27,6% пациентов с экстрагонадной формой новообразований, 85,8% человек с крестцово-копчиковой локализацией, 9,5% пациенток с расположением в матке и 4,7% – во влагалище. Рабдомиосаркома выявлена у 25,4%, нейробластома – у 4,5% и примитивная нейроэктодермальная опухоль – у 1%. УЗИ выполнены на сканерах Philips IU22 (USA), Logic 400 MD (GE, USA) конвексными датчиками (3,5–5,5 МГц) по стандартной методике в серошкальном режиме, в режимах цветового и энергетического допплеровского картирования.
Результаты. На первом этапе диагностики установлено, что для злокачественных новообразований малого таза характерны неправильная форма, которая встречалась у 97 (88,2%; $p<0,0001$), неровные, нечеткие контуры – 94 (85,5%; $p<0,0001$), неоднородная эхоструктура – 102 (92,7%; $p<0,0001$), у 70 человек (63,6; $p=0,001$) за счет кистозных включений, у 37 (33,6%; $p>0,05$) наблюдались кальцинированные включения, акустическая плотность опухолей у 75 детей (68,2%) $p=0,001$ была пониженной. При допплерографии у наибольшего количества пациентов (100 (90,9%)) регистрировался гиперинтенсивный внутриопухолевый кровоток преимущественно артериального типа с диапазоном максимальных артериальных скоростей (МАС) от 12,5 до 45 см/с, среднее значение МАС – 30±2,7 см/с. Специфичность метода составила 86,3% ($p=0,001$), чувствительность – 85,2% ($p=0,011$), точность – 87,5% ($p=0,014$). В ходе лечения, после каждого курса полихимиотерапии, осуществлялся ультразвуковой контроль, мы оценивали изменения в размерах, структуре и неоваскуляризации новообразований, что позволяло оценить эффективность противоопухолевого лечения.
Заключение. Комплексная сонография является важным методом в первичной диагностике злокачественных тазовых опухолей в детском возрасте и приоритетным методом на этапах мониторинга противоопухолевого лечения, позволяющим определить степень распространенности опухолевого процесса и избежать многократной лучевой нагрузки на растущий детский организм.

Ключевые слова:
опухоли полости таза, дети, герминогенные опухоли, нейробластома, рабдомиосаркома, ультразвуковое исследование

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INTRODUCTION

Neoplasms in the projection of the small pelvis in children are a rare pathology, which accounts around 0.5–2% of the total structure of childhood cancer incidence [1, 2]. The early diagnosis of these neoplasms is an urgent problem. Parents seek medical care only at stages III–IV due to the long preclinical phase of the disease, the appearance of the first symptoms associated with pelvic organ dysfunction only when reaching large tumor sizes, and the inability to get reliable information about complaints from small patients [3, 4].

The updated topical diagnosis and assessment of the prevalence of the tumor process in the pelvic cavity in children allows us to determine the feasibility and scope of surgical intervention. Radiation diagnostics (ultrasound, spiral x-ray computed tomography, magnetic resonance imaging) plays a leading role in the whole set of laboratory and instrumental methods for diagnosing pelvic tumors in children [5, 6]. Among all instrumental diagnostic methods, ultrasound diagnostics is the most accessible, non-invasive method of visualization of pelvic cavity tumors, a method of primary, differential, screening diagnostics that does not have a radiation effect on the growing body and does not require anesthesia during the study. After establishing the fact of the presence of a mass lesion in the pelvic cavity, computer tomography and other methods of instrumental diagnostics are performed in order to confirm the diagnosis and clarify the prevalence of the tumor process [7].

Purpose of the study: to assess the potential of sonography in the diagnosis of pelvic tumors in children.

PATIENTS AND METHODS

We retrospectively analyzed the protocols of ultrasound examinations of the pelvis, abdominal cavity and retroperitoneal space of 110 children with malignant tumors of the pelvic cavity who were examined and treated at the National Medical Research Centre for Oncology of the Ministry of Health of Russia, with the identification of the most significant parameters of neoplasms, such as: shape, size, volume, contours, echodensity, echo structure, prevalence of the process, neovascularization. For retrospective analysis we used statistical data of organizational-methodical Department, National Medical Research Centre for Oncology of the Ministry of Health of Russia, notifications about newly diagnosed patients, control charts of dispensary monitoring, inpatient and outpatient charts, surgical operating logs, results of histological and laboratory tests. All parents of children with pelvic tumors gave their voluntary informed consent for the use of the material removed during surgery for scientific purposes.

76 (69.1%) people with germ cell tumors were observed, including 55 (72.4%) patients with gonadal and 21 (27.6%) patients with extragonadal tumors, 18 (85.8%) people with sacrococcygeal tumors, 2 (9.5%) patients with tumors in the uterus and 1 (4.7%) in the vagina. Rhabdomyosarcoma was detected in 28 children (25.4%), neuroblastoma in 5 children (4.5%) and a primitive neuroectodermal tumor in 1 (1%) child.

By gender, the children were distributed as follows: germ cell tumors in 70 (92.1%) girls and 6 (7.9%) boys, rhabdomyosarcoma in 8 (28.5%) girls and 20 (71.5%) boys, neuroblastoma in 2 (40%) girls and 3 (60%) boys, primitive neuroectodermal tumor (PNET) in 1 boy.

The age composition of patients included in the study ranged from 1.5 months to 14 years.

Ultrasonography was performed on ultrasound devices Philips IU22 (USA), Logic 400 MD (GE, USA) with broadband convex transducers (3.5–5.5 MHz).

Abdominal gray-scale ultrasound imaging was used for ultrasound biometry and evaluation of the status and echostructure of the pelvic organs: the uterus and appendages in girls, prostate gland area in boys, bladder, bowel loops, sacrococcygeal region; the existence of the tumor was stated. The next step included measuring the volume of the tumor and evaluation of its echostructure, shape, contours, and extent. During dopplerography (DG) in the modes of color Doppler and power Doppler imaging (CDI, PDI),

the condition of the main vessels was evaluated, and a qualitative assessment of neovascularization was performed: the number and form of pathological vascular loci, the type of blood supply and its intensity. Dopplerometry (DM) measured the rate of intra-tumor blood flow.

Transabdominal ultrasound with retrograde bladder filling was performed in 2 (1.8%) children to clarify the degree of prevalence of the process [8].

Ultrasound monitoring during treatment is one of the most popular branches in oncopediatrics. We performed pelvic and abdominal ultrasound after each cycle of PCT.

Statistical processing was performed using the program STATISTICA 12.0 (StatSoft, USA). In this case, we used a frequency analysis module, which calculated the absolute and relative (in%) frequency of features, the confidence probability p for the difference of alternative states in the group. Diagnostic accuracy, sensitivity and specificity of ultrasound methods were determined according to standard principles of evidence-based medicine. The range of values was used and the average trend was estimated in the form of an average sample and its error, while assessing the variability of quantitative characteristics.

THE RESULTS OF THE STUDY AND DISCUSSION

In the studied group of children diagnosed with germ cell tumors, the abnormal form of neoplasms prevailed in 71 patients (93.5%), uneven, indistinct contours in 70 children (92.2%), solid-cystic echo structure in 56 cases (73.7%) with calcified inclusions in 21 (27.6%) patients. The echodensity of neoplasms in 40 people (52.6%) was hypoechoic and in 36 (47.4%) mixed.

The ultrasound picture of rhabdomyosarcoma was characterized mainly by an irregular shape in 22 patients (78.6%) with uneven, indistinct contours in 19 (67.8%), solid echo structure in 17 (60.7%), mixed echogenicity of 17 (60.7%) with anechogenic zones of necrosis and hemorrhage in 11 (39.3%) and calcified inclusions in 12 (42.9%).

Neuroblastomas had an irregular shape 4 (80%), bumpy, indistinct contours 4 (80%), solid echo structure with calcified inclusions 4 (80%), reduced echo density in 3 (60%) patients, mixed echo density in 2 (40%) patients.

We observed one child with PNET. The B-mode located a tumor of an oval shape, with bumpy, indistinct contours, mixed echo density, solid-cystic echo structure.

In the examined group of children, the minimum linear size of the tumor according to ultrasound was 2.0 cm, the maximum size 14.5 cm.

We did not detect pathognomonic sonographic differences between pelvic malignancies in children and considered it possible to combine them into a single group.

Thus, at the first stage of diagnosis, it was found that malignancies of the pelvis were characterized by an irregular shape observed in 97 (88.2%; $p<0.0001$), uneven, indistinct contours — 94 (85.5%; $p<0.0001$), heterogeneous echostruc-

Table 1. The distribution of the sonographic features of malignant tumors of the pelvis in children

The sign	abs. number	%	*p*
the irregular shape	97	88.2	$p<0.0001$
Heterogeneous structure of the tumor	102	92.7	$p<0.0001$
The contours of the tumor are rough and indistinct	94	85.5	$p<0.0001$
Cystic inclusions in tumors	70	63.6	$p=0.001$
Calcified inclusions in tumors	37	33.6	$p>0.05$
Hypoechoic acoustic echodensity	75	68.2	$p=0.001$

ture 102 (92.7%; $p<0.0001$), in 70 people (63.6%; $p=0.001$) due to cystic inclusions, in 37 (33.6%; p>0.05) calcified inclusions were observed, and the echodensity of tumors in 75 children (68.2%) $p=0.001$ was reduced (table 1).

CDI in the majority of patients — 100 (90.9%) registered hyperintensive intra-tumor blood flow of mainly arterial type with a range of maximum arterial velocities (MAV) from 12.5 to 45 cm/s, the average value of MAV = 30±2.7 cm/s.

The accuracy of the method was 87.5% ($p=0.014$), sensitivity 85.2% ($p=0.011$), specificity 86.3% ($p=0.001$).

All children included in the study were given polychemotherapy as the first stage of treatment. Before each subsequent cycle of PCT, a comprehensive ultrasound of the pelvic organs was performed. Based on changes in the echographic picture of neoplasms, we concluded that induction therapy was effective.

Thus, in 78 children (71%) with a significant and partial effect of treatment, we observed a decrease in the volume of the tumor by 55–90%, a change in the contours of neoplasms, they became smoother and clearer in 52 patients (66.6%) of 78. However, in 26 (33.4%) with a

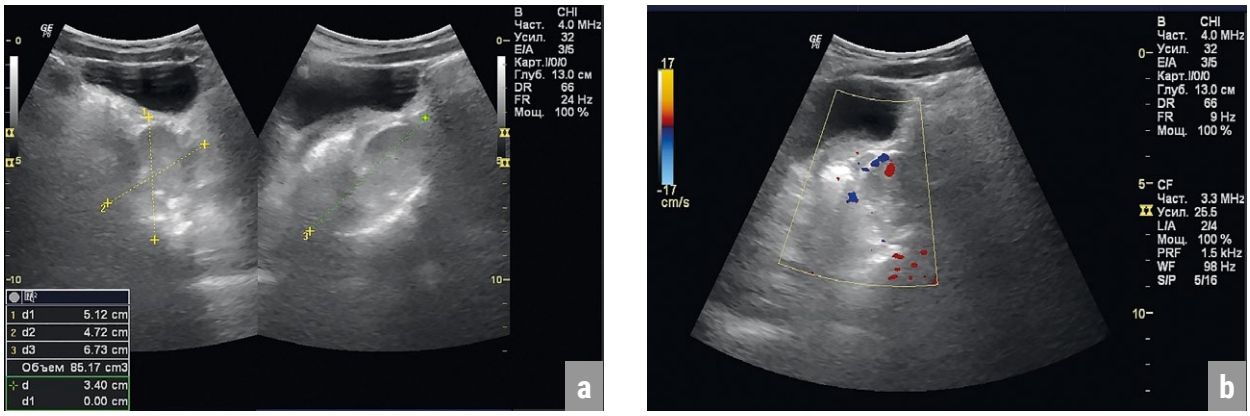

Fig. 1. Patient M., 1 year and 5 months old. Echogram of a germ cell tumor before treatment
a) B-mode – solid hypoechoic neoplasm, irregular shape, heterogeneous echostructure with single hyperechoic, calcified inclusions, the contours of the tumor are fuzzy, rough, sized 4.7x5.1x6.7 cm, the volume of the neoplasm is 85.17 cm^3
b) The CDI mode – isointensive intranodular bloodstream

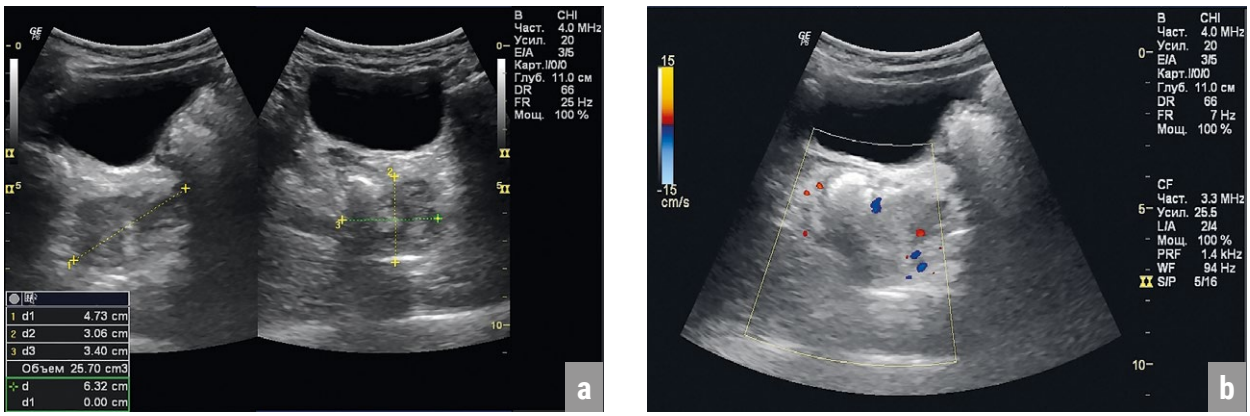

Fig. 2. Patient M., 1 year and 5 months old. Echogram of a germ cell tumor after 1 cycle of polychemotherapy:
a) B-mode – solid volume, hypoechoic neoplasm, irregular shape, size 3.0×3.4×4.7 cm, volume 25.7 cm^3, contours are fuzzy, uneven, inhomogeneous echo structure with single calcified, hyperechoic inclusions
b) CDI mode – hypointensive intranodular blood flow, MAV is 12 cm/s

significantly (by over 85%) decreased tumor volumes, contour visualization deteriorated sharply. The echo structure of tumors became more homogeneous in 40 patients (51.3%). In 31 patients (39.7%), an increase in the echodensity of tumors was observed during treatment. Also, the degree of vascularization of tumors decreased with a decrease in blood flow parameters, up to its complete disappearance in 9 children (11.5%).

To illustrate the effectiveness of ultrasound in antitumor treatment monitoring, here we present clinical cases.

Clinical case № 1.

Patient M., 1 year and 5 months old. Clinical diagnosis: Pelvic germ cell tumor with spread to the soft tissues of the sacro-coccygeal region, with metastatic lesions of the coccygeal vertebrae, lungs, stage IV, clinical group 2.

Ultrasound examination determined a bulk solid hypoechogenic lesion in the pelvic cavity posterior to the uterine body, with an irregular shape, heterogeneous echo-structure with single hyperechogenic, calcified inclusions, the tumor contours fuzzy, rough, size 4.7×5.1×6.7 cm, tumor volume 85.17 cm³; DG recorded iso-

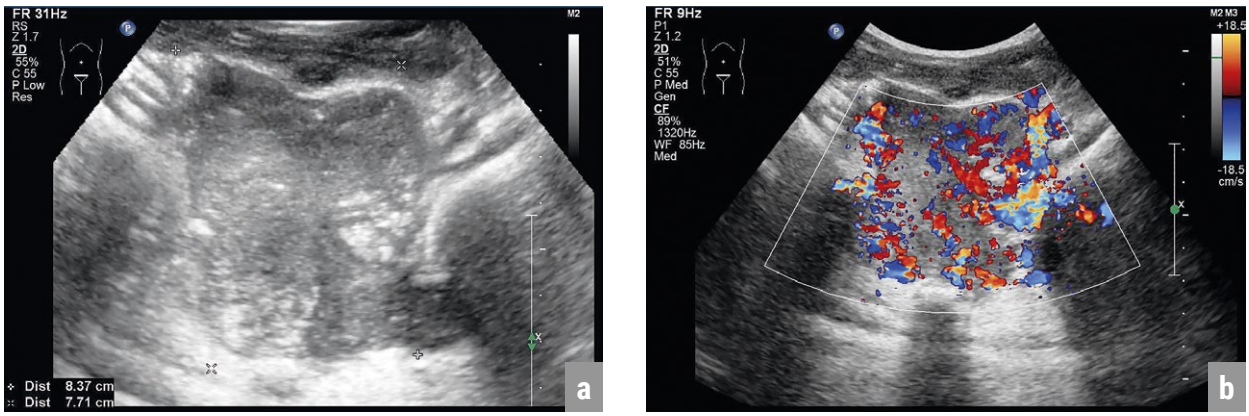

Fig. 3. Patient M., 1 year old. Neuroblastoma echogram before treatment
a) B-mode – volume hypoechoic nodular solid neoplasm with the size of 8.37×7.7×7.0 cm, volume of 451 cm³ with uneven, fuzzy contours, multiple hyperechoic calcified inclusions
b) CDI mode – hyperintensive intra-tumor blood flow in the central and peripheral zones

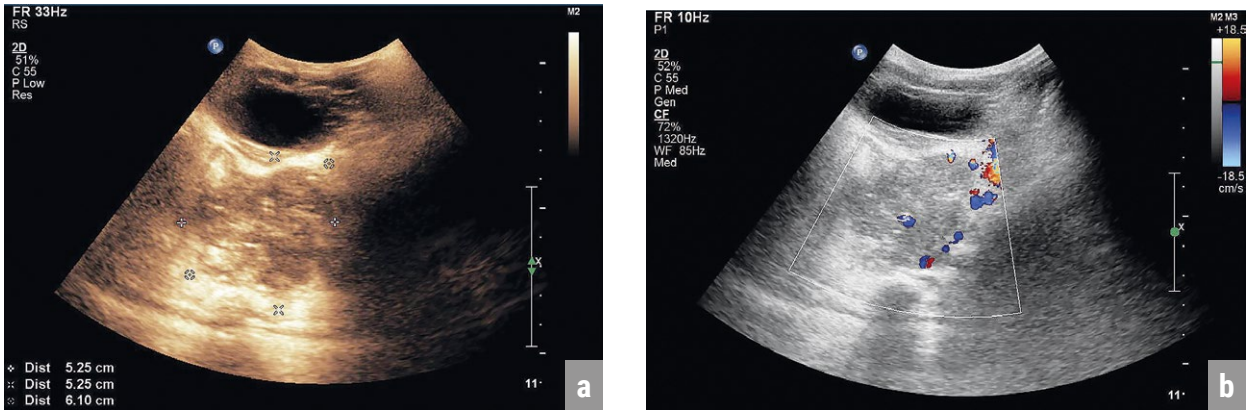

Fig. 4. Patient M., 1 year old. Neuroblastoma echograms after the 2nd cycle of PCT:
a) B-mode – hypoechoic nodular neoplasm, solid, heterogeneous echostructure with single calcified inclusions, with rough, indistinct contours, size 5.25×5.25×6.1 cm, volume 168 cm³
b) CDI mode – hypointensive intratumor bloodstream

intense intratumoral blood flow, arterial type, MAV=25 cm/s. (Fig. 1 a, b).

After the first cycle of polychemotherapy, ultrasound determined a solid, hypoechoic neoplasm of irregular shape in the projection of the pelvis posterior to the uterine body, size 3.0×3.4×4.7 cm, volume 25.7 cm³, with fuzzy, uneven contours, heterogenous echo structure with single calcified, hyperechoic inclusions; DG recorded intra-tumor blood flow of low intensity, MAV 12 cm/s. (Fig. 2 a, b).

We regarded this example as a positive dynamics of the disease — the effective sensitivity of tumors to PCT, the volume of the tumor after the first cycle decreased by 70%, and the tumor hypovascularization was noted.

Clinical case № 2.

Patient M., 1 year old. Clinical diagnosis: Retroperitoneal neuroblastoma, stage III, clinical group 2.

Ultrasound examination determined a volumetric hypoechoic nodular solid neoplasm centrally in the pelvic cavity, with the size of 8.37x7.7x7.0 cm, volume of 451 cm³ with rough, indistinct contours, multiple hyperechoic calcified inclusions. DG reg-

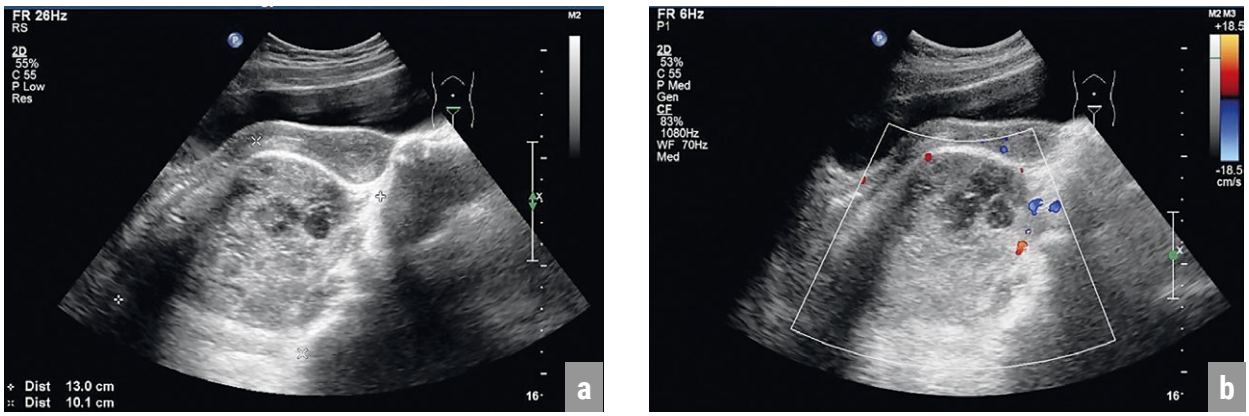

Fig. 5. Patient H., 12 years old. Echogram of PNET before treatment
a) B-mode – solid neoplasm, oval shape, size 13.0×10.0×9.5 cm, volume 617.5 cm³, contours are fuzzy, uneven, heterogeneous, solid-cystic echo structure, mixed echo density.
b) the CDI mode – isointensive peripheral arterio-venous bloodstream

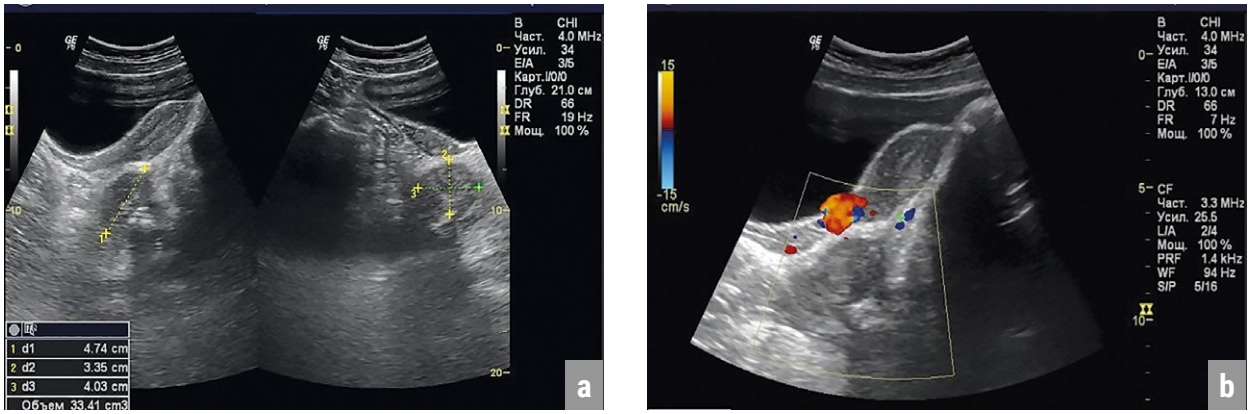

Fig. 6. Patient H., 12 years old. Echogram of PNET after 3 cycles of PCT
a) B-mode – solid neoplasm size 4.7×3.3×4.0 cm, V=33.4 cm³, contours are fuzzy, uneven, solid-cystic, heterogeneous echo structure, reduced echo density
b) CDI mode – single vascular loci on the periphery

istered hypervascularization of neoplasms in the central and peripheral zones, arterial type throughout, MAV was up to 67 cm/s. (Fig. 3 a, b).

After two cycles of polychemotherapy, ultrasound determined a hypoechoic nodular neoplasm centrally in the pelvic cavity, solid, heterogeneous echo structure with single calcified inclusions, with rough, indistinct contours, size 5.25×5.25×6.1 cm, volume 168 cm³. In DG, hypointensive intra-tumor blood flow was registered mainly in the peripheral parts, MAV was up to 18 cm/s (Fig. 4 a, b).

We regarded this example as a positive dynamics of the disease — the effective sensitivity of the tumor to PCT, because the volume of the tumor decreased by 63%, tumor echostructure became more homogenous, the number of calcified inclusions decreased; the tumor hypovascularization was noted, and parameters of arterial intratumoral hemodynamics decreased by 70%.

Clinical case № 3.

Patient H., 12 years old. Diagnosis: Primitive neuroectodermal pelvic tumor spreading to the soft tissues of the left gluteal region, destruction of the sacrum and left iliac bone, lung metastases, stage IV, high-risk group, clinical group 2.

Ultrasound examination determined an oval solid mass in the pelvic cavity behind the uterus and close to the sacrum, with the size of 13.0x10.0x9.5 cm, volume of 617.5 cm³ with indistinct uneven contours, solid and cystic echostructure, mixed echodensity. DG registered isointense intratumoral arterial venous blood flow, MAV = 15 cm/s. (Fig. 5 a, b).

After three cycles of polychemotherapy, the ultrasound determined a solid volume neoplasm in the pelvic cavity with dimensions of 4.7x3.3x4.0 cm, V=33.4 cm³, with fuzzy, uneven contours, heterogeneous echo structure with single cystic inclusions, reduced echo density; DG recorded single vascular loci along the periphery (Fig. 6 a, b), MAV= 7 cm/s

We regarded this example as a positive dynamics as well, effective sensitivity to the treatment of the tumor process, since the volume of the tumor decreased by 94.5%, the echo structure became more homogenous, the number of cystic inclusions decreased, and significant hypovascularization of the tumor was noted.

CONCLUSION

1. Complex sonography is an important method in the primary diagnosis of pelvic tumors in childhood. The accuracy of the method was 87.5% (p=0.014), sensitivity 85.2% (p=0.011), specificity 86.3% (p=0.001).

2. Ultrasound is a sensitive and priority diagnostic method in monitoring the dynamics of the tumor process during the ongoing treatment, which allows avoiding multiple radiation loads on the growing body and planning the surgical stage.

Authors contribution:
Maksimova N.A. – research concept and design, scientific editing, ultrasound examinations, preparation of illustrations.
Kozel Yu.Yu. – scientific editing, treatment of patients.
Ilchenko M.G. – data collection, analysis and interpretation, ultrasound examinations, technical editing, article preparation.
Mkrtchyan G.A. – data collection, treatment of patients.

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