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METHOD OF ULTRASOUND ASSESSMENT OF THE NATURE AND SEVERITY OF A CLOSED ABDOMINAL INJURY

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Aim. To study the possibilities of ultrasound examination (ultrasound) in assessing the nature and severity of closed abdominal trauma (CAT) and determining the surgical treatment tactics for this pathology.

Material and methods. Ultrasound was performed in 160 patients with closed abdominal trauma as an initial method for diagnosing intra-abdominal injuries and was completed in the emergency department immediately upon admission to the clinic. The main criteria for inclusion of patients in the study were age 18 years and older and stable hemodynamic parameters (BP \geq 90 mm Hg) at the time of surgery.

Results. Among the various sonographic semiotics of intra-abdominal lesions in PTZ, the most constant ultrasound signs are the presence of multiple volumes of free fluid in the abdominal cavity. The sensitivity, specificity, and accuracy of ultrasound in detecting free fluid in the abdominal cavity seem to be relatively high and amount to 88.3, 87.8, and 88.1%, respectively. The highest relative risk (RR = 4.862; 95% CI 3.074-7.692) was associated with a free fluid volume in the abdominal cavity of more than 500 ml, with the probability of a severe intra-abdominal injury (EER) is 93.5%.

Conclusion. The developed method of ultrasonic assessment of the volume of free fluid in the abdominal cavity, based on the thickness of the fluid layer and its prevalence in the areas of the abdominal cavity, does not complicate or lengthen the procedure of the FAST protocol; it allows to determine the critical volumes of hemoperitoneum, which are of decisive importance in choosing the tactics of surgical treatment of prostate cancer.

Keywords: closed abdominal trauma, diagnostics, ultrasound, calculation of free fluid volume, choice of treatment tactics.

Introduction

In the choice of tactics of surgical treatment of closed abdominal trauma (CAT), it is important to assess the quantitative score of the volume of the flowed blood and ultrasound identification of the severity of injury of internal organs of the abdominal cavity, mainly parenchymal organs. For today, in emergency surgery, the injuries of the abdomen of the initial methods of instrumental examination of the abdominal organs is an ultrasounography, which is aimed at improving the quality of assistance to injured patients by early detection of damage, especially when these states are potentially life-threatening, and the outcome of surgical treatment depends on its time. Given the importance of ultrasound in the diagnosis of intra-abdominal complications of injury and when performing a wide range of smal invasive medical diagnostic procedures under the sonographic guidance with various urgent states, American College Surgeons included in its advanced protocol of training courses for doctors of emergency medicine, using the Fast Protocol when assisting victims (Advanced Trauma Life Support - ATLS) [1]. Moreover, Agency for Healthcare Research and Quality (AHRQ) has included in its clinical guidelines to fulfill the catheterization of the central veins under ultrasound control in order to increase security Procedures [2]. Similarly, American Society Of Echocardiography - (ASE) together wwit American College of Emergency Physicians (ACEP) developed a focused protocol Cardiac Ultrasound (Focus) for emergency conditions [3]. The protocols of organ examination are actively developed, which are traditionally considered poorly sustainable sonographic visualization (lungs, pancreas).

The purpose. Studying the diagnostic efficacy of sonography in identifying signs of damage of the abdominal organs and a detailed description of ultrasonic semiotics of the CAT.

Materials and methods

Ultrasound was performed in 160 patients with closed abdominal trauma as an initial method for diagnosing intra-abdominal injuries and was performed in the emergency department immediately upon admission of the patient to the clinic. The main criteria for inclusion of patients in the study were age 18 years and older, as well as stable hemodynamic parameters ($BP \geq 90$ mm Hg) at the time of the start of surgery.

The transabdominal ultrasound was performed using the Mindray DC-40 (PRC) apparatus using a convex sensor 3.5 MHz and 5 MHz linear sensors and 7.5 MHz without prior preparation of the patient.

In order to assess the significance of various amounts of hemoperitoneum (<300 ml, 300-500 ml and > 500 ml) in patients with the CAT with stable hemodynamic parameters, the values of their relative risk (op or RR, from English. "Relative Risk") in predicting heavy intra-abdominal complications of injury was done. At the same time, the degree of a statistically reliable association of these 3-range hemoperitoneum volumes with the probability of detection of heavy intra-abdominal damage was ranked on: dubious (RR = 0-1.0); probable (RR = 1.0-3.0); Absolute (RR > 3.0).

Results and discussion

Our observations show that patients with CAT with sensitivity (SE), specificity (SP) and accuracy (AC) of the ultrasound in identifying one of the main signs of injury - free fluid (hemoperitoneum) in the abdominal cavity stands, respectively, 88.3, 87.8 and 88.1% (Table 1), which is not considered as rather high indicator based on the modern standards.

Table 1. Informativeness of the ultrasound in identifying signs of the CAT, n = 160

Ultrasound sign	TP	FP	TN	FN	Se	Sp	Ac	VPV	NPV
Free liquid	98	6	43	13	88,3%	87,8%	88,1%	94,2%	76,8%

Note:

Tr - true positive results, FP - false positive results, TN - True negative results, FN - False negative results, SE - Sensitivity, SP - Specificity, AC - Test Accuracy, VPV – Positive predictive value, NPV - Prognostic value of a negative result (Negative Predictive Value).

However, the sonographic signs of the free fluid in the abdominal cavity in patients with the CAT can serve as a relatively reliable criterion that allows to predict the presence of intra-abdominal injury complications with a high certainty, since the indicator is prognostic value of the positive result (VPV) on this criterion is 94.2% (Table 1). At the same time, it is crucial that the absence of pathological traffic in the abdominal cavity on ultrasound does not always exclude the presence of an injury of the abdominal organs and cannot serve as a contraindication to surgical intervention. Thus, our calculations of the prognostic value of a negative result (NPV) on the diagnostic sign "Free liquid in the abdominal cavity" show a low value (76.8%) of this criterion in a significant exclusion of abdominal injury.

In the study of the feasibility and efficiency of the use of the Songographic criterion "The presence of free fluid in the abdominal cavity" in determining the tactics of surgical treatment of patients with the CAT arose the need for the development of the method of measuring the volume of hemoperitoneum. To solve this problem, 67 patients were selected from the CAT, which had an estimate of the ratio of the hemoperitoneum, the estimated intraoperative, and the widths and prevalence of the free fluid in the abdominal cavity, estimated by an ultrasound (Table 2).

Table 2. The volume of intraoperatively determined blood in the abdominal cavity depending on the ultrasound data of the layer width and the prevalence of free fluid, n=67

Free liquid layer width	1 area		2 area		>3 area	
	V free.liquid.	n	Vfree.liquid.	n	Vfree.liquid	n
<1 cm	169,2±72,3	13	418,2±160,1	11	633,3±152,8	3
1-2 cm	250,0±129,	4	575,0±103,5	8	1233,3±111,	9

	1				8	
2-3 cm	450,0±129, 1	4	966,7±57,7	3	1740,0±207, 4	5
3-4 cm	600	1	1233,3±152, 8	3	2500	1
>4 cm	500	1	1600	1	-	0
Всего	265,2±163, 4	23	669,2±359,7	26	1144,4±608, 0	18

Our calculations show that the presence of a thin (up to 1 cm) strip of free fluid within one anatomical region indicates a hemoperitoneum volume of up to 200 ml. With the accumulation of up to 300 ml of blood in the abdominal cavity, the ultrasound picture is characterized by the presence of a layer of free fluid up to 2 cm wide within 1 anatomical region. For hemoperitoneum with a volume of 300-500 ml, visualization of a strip of free fluid up to 2 cm thick is typical, extending to 2 anatomical regions of the abdomen, or the presence of fluid within one area, but with a thickness exceeding 3 cm or more. Detection of free fluid in the abdominal cavity on ultrasound, extending to 3 or more areas indicates the presence of hemoperitoneum with a volume of more than 500 ml. The same volume of blood is also indicated by the presence of free fluid with a layer thickness of more than 2 cm on ultrasound in 2 areas, or any accumulation of free fluid with a thickness of more than 3 cm (Table 2).

The above calculations comparing the prevalence and thickness of the sonographically detected free fluid with the volume of intraoperative blood removed from the abdominal cavity made it possible to develop the "Scale for ultrasound assessment of hemoperitoneum volume in patients with abdominal trauma" (Table 3).

Table 3. Scale of ultrasound-estimates of hemoperitoneum in patients with abdominal injury

Fluid layer width	1 area	2 area	>3 area
<1 cm	<200	300-500	500-1000
1-2 cm	200-300	300-500	1000-1500
2-3 cm	300-500	500-1000	1500-2000
3-4 cm	300-500	1000-1500	>2000
>4 cm	300-500	1500-2000	>2000

In order to assess the practical significance of preliminary measurement of the volume of free fluid in the abdominal cavity using ultrasound in patients with CAT, we decided to compare the volume of intraoperatively detected blood in the abdominal cavity (actual volume) with the nature and extent of the surgical intervention performed (Table 4). Thus, in 44 (28.4%) patients with a volume of free fluid in the abdominal cavity up to 300 ml, situations almost never occurred that required a mandatory wide laparotomy. Moreover, with this amount of free fluid (<300 ml), in 20.5% of cases (n=9) surgeons deal with stopped intra-abdominal

bleeding, and therefore the volume of surgical intervention is limited only to debridement and drainage of the abdominal cavity.

Table 4. Comparison of the volume of hemoperitoneum with the volume of surgical intervention performed, n=155

Intervention	<300 ml, n=44		300-500 ml, n=34		>500 ml, n=77	
	abs.	%	abs.	%	abs.	%
Debridement and drainage of the abdominal cavity	9	20,5	1	2,9	-	0,0
Electrocoagulation of a bleeding vessel	23	52,3	6	17,6	3	3,9
Suturing a gap \geq I st. according to Moore of parenchymal organ	6	13,6	10	29,4	2	2,6
Suturing of the desorized areas of the intestine, ruptures of the mesentery and the greater omentum	6	13,6	2	5,9	-	0,0
Suturing a gap \geq II st. according to Moore of parenchymal organ	-	0,0	6	17,6	24	31,2
Precision and removal of the organ	-	0,0	7	20,6	44	57,1
Suturing the wall of the hollow organ	-	0,0	2	5,9	4	5,2

Note: the table does not include 5 (3.1%) patients out of 160 patients in whom damage to the internal organs and hemoperitoneum were not detected intraoperatively.

Here we would like to point out as a discussion that today there are numerous experimental and clinical studies [4,5,6], proving the possibility of spontaneous resorption of a sufficiently large volume of blood from the abdominal cavity, there is a need for additional study of the advisability of expanding and concretizing the indications for conservative treatment of CAT in patients with ultrasound or MSCT with signs of a small volume of hemoperitoneum without clinical signs of ongoing internal bleeding. Moreover, our observations on the management of patients with a volume of free fluid in the abdominal cavity less than 300 ml (n=44) show that with this volume of hydroperitoneum in patients with CAT, there are practically no cases of damage to the hollow organs of the abdominal cavity.

In cases where the volume of intra-abdominal blood loss is 300-500 ml (n=34), more than half of the patients (19; 55.9%) underwent intraoperative surgical manipulations and procedures, such as debridement and drainage of the abdominal cavity, electrocoagulation of a bleeding vessel, suturing the gap I st. according to Moore of the parenchymal organ, suturing of the desorized areas of the intestine, ruptures of the mesentery and the greater omentum, without any special technical difficulties, can be performed using the laparoscopic technique using routinely used

instruments without the use of expensive consumables. And taking into account the above 44 patients, in whom the volume of hemoperitoneum did not exceed 300 ml, the proportion of patients potentially subject to elimination of intra-abdominal complications of trauma by laparoscopic method without the use of a wide laparotomy increases to 80.8% (63 patients out of 78) (Table 4).

In the presence of more than 500 ml of blood in the abdominal cavity (n=77), the possibilities for the use of laparoscopic techniques were extremely limited and occurred only in 5 (6.5%) patients (Table 4).

Our calculations show that the presence of up to 300 ml of blood in the abdominal cavity on ultrasound excludes with a high probability (RR=0.000) the presence of serious intra-abdominal injuries requiring a wide laparotomy. With a free fluid volume in the range of 300-500 ml, the “absolute risk of having significant damage to the abdominal organs” is 44.1% (EER = 0.441), and the relative risk (RR) is 0.472 units (doubtful sign). The highest relative risk (RR) was associated with a free fluid volume in the abdominal cavity of more than 500 ml, when the probability of having a serious intra-abdominal injury (EER) is 93.5%, and the relative risk seems to be absolute and is 4.862 units with 95% CI in the range from 3.074 to 7.692 units (Table 5).

Table 5. Relative risk (RR) value for severe intra-abdominal injuries with different volumes of free fluid in the abdominal cavity

Indicator	The volume of hemoperitoneum, ml		
	<300	300-500	>500
Absolute risk in the presence of factor (EER)	0.000	0,441	0.935
Absolute risk in the absence of factor (CER)	0.935	0,935	0.192
Relative risk (RR)	0.000	0,472	4.862
Standard Relative Risk Error (S)	∞	0,195	0.234
Lower border 95% (CI)	0.000	0,322	3.074
Upper border 95% (CI)	NaN	0,692	7.692
Sensitivity (Se)	0.000	0,172	0.828
Specificity (Sp)	0.102	0,208	0.926

Taking into account the high informative value of the ultrasound indicator “volume of free fluid in the abdominal cavity” in predicting the severity of intra-abdominal injuries, we developed the “Algorithm for choosing the tactics of surgical treatment of CAT based on ultrasound assessment of the volume of free fluid in the abdominal cavity” (Fig.1).

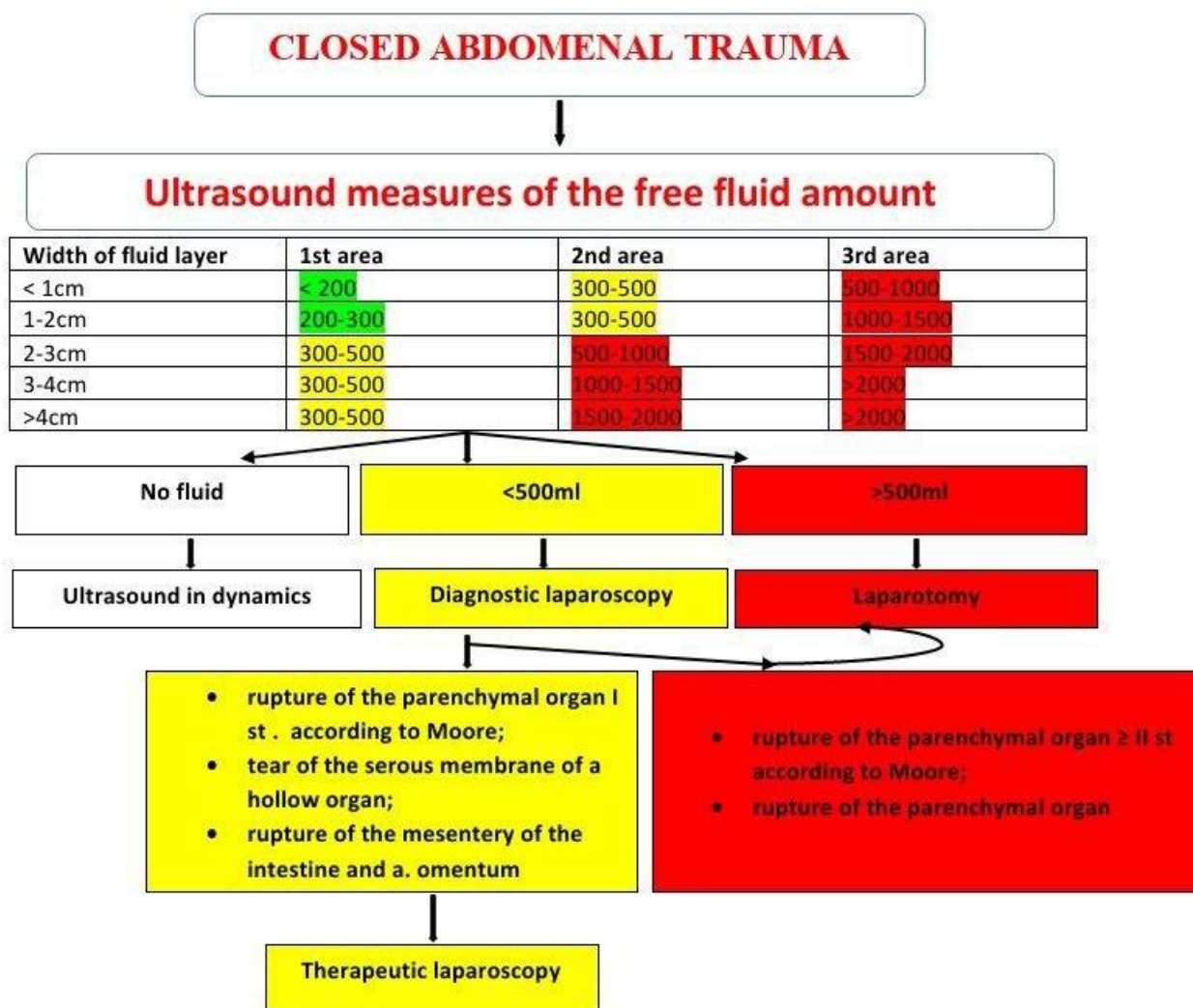


Fig 1. Algorithm for choosing the tactics of surgical treatment of CAT based on ultrasound assessment of the volume of free fluid in the abdominal cavity

Conclusion

Among the various sonographic semiotics of intra-abdominal lesions in CAT, the most constant ultrasound signs are the presence of various volumes of free fluid in the abdominal cavity. The sensitivity, specificity and accuracy of ultrasound in detecting free fluid in the abdominal cavity seems to be quite high and amount to 88.3, 87.8 and 88.1%, respectively. The proposed approach to ultrasound assessment of discrete volumes of free fluid in the abdominal cavity, based on the thickness of the fluid layer and its prevalence in the abdominal cavity, does not complicate or lengthen the FAST protocol procedure, and allows determining the critical volumes of hemoperitoneum, which are crucial in the choice of surgical tactics for treatment of CAT.

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