Chirurgia (2013) 108: 643-651
No. 5, September - October

The Role of Intraoperative Ultrasound in Establishing the Surgical Strategy Regarding Hepato-Bilio-Pancreatic Pathology

S. Cirimbei[1], C. Pușcu[2], L. Lucenco[1], E. Brătucu[1]

[1]Surgery Department No.1, Oncologic Institute Bucharest, Romania
[2]Surgery Department, Universitary Hospital "Sfântul Pantelimon" Bucharest, Romania

Rezumat

Locul echografiei intraoperatorii în stabilirea strategiei chirurgicale în patologia hepato-bilio-pancreatică

Echografia intraoperatorie joacă un rol din ce în ce mai important în chirurgia abdominală pe cale deschisă sau laparoscopică, răspunzând nevoii chirurgului de a caracteriza mai corect leziunile, aducând beneficii privitoare la topografia şi extensia loco-regională, raporturile cu structurile de vecinătate şi în final stadializarea bolii. Echografia intraoperatorie este utilizată în special în intervențiile la nivelul tractului hepato-bilio-pancreatic, având atât valențe diagnostice cât şi terapeutice. În perioada 2009-2012 în Clinica Chirurgie 1 din cadrul IOB s-au efectuat 57 de echografii intraoperatorii, la pacienți cu patologie din sfera hepato-bilio-pancreatică, realizându-se puncții ghidate intraoperator în scop diagnostic sau terapeutic (în cazul abceselor hepatice), decelarea de noi metastaze hepatice, radioablația acestora sub control echografic, explorarea topografiei locoregionale în vederea unei rezecții hepatice optime. Echografia intraoperatorie a permis realizarea radioablației sub ghidaj echografic la 43 de pacienți, majoritatea prezentând metastaze hepatice multiple în zone diferite, metoda facilitând şi controlul distrucției lezionale complete. De asemeni au fost detectate în 11 cazuri (22,91%), un număr de 20 metastaze hepatice omise imagistic preoperator, tratate ulterior prin RFA; totodată în 14 cazuri echografia intraoperatorie a elucidat prezența şi natura tumorilor hepatice, conducând la un diagnostic histopatologic corect şi o terapie adecvată. Metoda a fost utilă şi în patologia pancreatică, forme complicate de pancreatită acută sau cronică, realizându-se reperarea canalul Wirsung, în masa scleroasă şi cu calcificări a țesutului pancreatic, printr-o puncție ghidată sonografic, precum şi localizarea maselor pancreatice chistice, cu stabilirea zonei optime de puncție sau de drenaj perichisto-digestiv. Echografia intraoperatorie este o metodă facilă, ieftină, rapidă, ce permite explorarea în timp real pe toată durata actului chirurgical, a leziunilor hepato-bilio-pancreatice, ajutând la modularea deciziilor operatorului şi la prevenirea complicațiilor.

Cuvinte cheie: echografie, intraoperator, tract hepato-bilio-pancreatic

Abstract

Intraoperative ultrasound examination plays a more and more important role in open or laparoscopic abdominal surgery, satisfying the surgeon's need to correctly characterize lesions, bringing various benefits regarding topography and local-regional extension, relations between neighbouring structures and, finally, disease staging. Intraoperative ultrasound is used especially in hepato-bilio-pancreatic tract interventions, given its diagnostic and therapeutic values. Between 2009-2012 in the IOB First Surgery Clinic 57 intraoperative echographies were performed, in patients with hepato-bilio-pancreatic

Corresponding author: Simona Cirimbei, MD
1st Surgical Clinic
The Oncological Institute of Bucharest
"Carol Davila" University of Medicine
and Pharmacy, Bucharest, Romania
E-mail: cirimbei@yahoo.com

pathologies, leading to intraoperative guided punctures with diagnostic or therapeutic purpose (in case of hepatic abscesses), detection of new hepatic metastases, their ablation under ultrasound guidance, exploration of the local-regional topography with the aim of an optimal hepatic resection. Intraoperative ultrasound allowed radioablation under echographic guidance in 43 patients, the majority presenting multiple hepatic metastases in different areas, this method also enabling control over complete lesional destruction. Also, in 11 cases (22.915), a number of hepatic 20 metastases which had not been visible on preoperative imaging scans were detected, and afterwards treated through RFA; also, in 14 cases intraoperative echography revealed the presence and nature of the hepatic tumours, leading to a correct histopathological diagnostic and an adequate therapy. The method was useful in pancreatic pathologies as well, in complicated forms of acute or chronic pancreatitis, tracking the Wirsung duct within the scleral and calcified mass of pancreatic tissue, through an ultrasound guided puncture, as well as in locating pancreatic cystic masses, determining the optimal puncture or pericystic-digestive drainage areas. Intraoperative ultrasound is an inexpensive, easy method, which allows real time exploration throughout the entire surgical process of hepato-bilio-pancreatic lesions, aiding the surgeon in modifying decisions regarding the intervention and preventing complications.

Key words: ultrasound, intraoperative, hepato-bilio-pancreatic tract

Introduction

Modern hepato-bilio-pancreatic surgery involves a very precise intraoperative evaluation of the lesions, given the tendency to implement new advanced surgical techniques, which are conservative, with a minimum of tissue excision, as well as minimally invasive techniques, which require a real time lesion description.

Intraoperative ultrasound exploration thus becomes an almost mandatory condition in hepatic, digestive and pancreatic surgery especially in connection to primary or secondary malignant tumours; this method playing an important role in determining those additional diagnostic elements, elements regarding structure and anatomical relations of the lesion, and, equally important, that enable intraoperative post-procedure control. By means of all the information thus provided, this method tends to gain more and more grounds when it comes to establishing a surgical strategy.

The first use of ultrasound imaging as an intraoperative method of exploration dates back to 1960, when it was used to localize kidney stones; initially without great success among doctors, it became a widely accepted method after the introduction of high frequency amplifiers and B-mode high resolution, in 1970. Lane and Glazer highlighted the value of this method in hepato-biliary explorations, using B-mode ultrasonography in the intraoperative exploration of the main bile duct, and comparing the method to classic intraoperative cholangiography.

At present, the advantages of this method are demonstrated mainly in hepatic surgery, where it achieves an exact localization of the lesion, describes the relation with neighbouring bilio-vascular structures, during those interventions that involve regular or atypical resections of the liver, local destruction interventions or other hepatic procedures. Concerning its utility in pancreatic surgery, this is mainly related to intraoperative localization of the Wirsung duct, to the detection of pancreatic tumoral foci and to describe of their relation, especially with neighbouring vascular elements.

In terms of accuracy, compared to other preoperative imagistic methods, it is considered that the sensitivity of intraoperative ultrasound imaging is significantly higher than even a CT or a MRI, reaching 94-96% for hepatic lesions of 3-5 mm. Thus, in a wide study conducted on 189 patients with colo-rectal cancer metastasized in the liver, Machi, J., Sigel, B (1) determine a diagnostic accuracy of 94% in the case of intraoperative ultrasound, compared to the significantly lower rates of preoperative ultrasound (74%), CT (75%) and intraoperative surgical explorations (80%).

Between 2009-2012 at the First Surgical Clinic of IOB, 57 intraoperative ultrasounds with 7.5 MHZ B-mode linear amplifier and Doppler echography were performed, hoping to detect and precisely localize the hepatic lesions, to explore the biliary branching and the pancreas.

Material and Method

The technique for performing intraoperative ultrasound

The first condition in performing a complete intraoperative hepato-bilio-pancreatic ultrasound is the preparation of a large surgical field, obtained through either a right subcostal incision, a left arched subcostal incision or a median xipho-subombilical incision, which would allow a good exposure of the hepatic surfaces. Liver visibility and access are afterwards considerably increased, through another essential surgical gesture, meaning by mobilizing the liver, by sectioning the round and falciform ligament, as well as the triangular ligaments. Conditions for an optimum ultrasound scan are thusly created, contact between the amplifier and the hepatic capsule being sufficiently ensured by the peritoneal liquid.

Visual and palpatory exploration of the liver, in accordance with the preoperative imagistic data, always precedes ultrasound exploration, and detects structural and global hepatic consistency elements.

The first ultrasound orientation elements are the 3 sub-hepatic veins, identified centripetal starting from the level of the "attack triangle" towards the periphery, having the inferior vena cava as a mark; the segmentary portal branches are checked centrifugal, starting from the hepatic hilum, tracing the configuration of the hepatic segments, according to

Couinaud's classification. The portal branches, together with the branches of the hepatic artery and the intrahepatic biliary ducts form Glissonian pedicles, destined for every hepatic segment, the identification of each intraglissonian anatomic structure being facilitated by the use of Doppler power, colour and pulse. Intrahepatic peripheral biliary ducts are not visible on an intraoperative ultrasound in the absence of dilations, an exception to this being some ducts from the left liver lobe; central ducts on the other hand are visible even under normal parameters. Identifying these anatomic elements is useful in establishing the exact relations between the hepatic tumours, the therapeutic approach being established in accordance to this as well - the resection type, resection or local destruction, if it is operable or non-operable.

Exploration of the parenchyma in order to determine tumoral lesions is performed through a sinusoidal scan, preferably starting from the lateral segments of the left lobe, towards the right lobe, intraoperative ultrasound being able thusly to actually determine lesions as small as 2 mm, with a sensitivity rate of over 90%. The purpose of this is to determine the number and dimension of the lesions, their topography, and to establish the hepatic segments involved. The contribution of intraoperative ultrasound is considered to be an important one, determining up to 15-30% more lesions than preoperative imaging. Colo-rectal cancer metastases are usually hypoechogeneous, with or without calcifications, making it necessary to distinguish them from haemangiomas, hepatic adenoms foci, cirrhotic nodules etc. Benign lesions usually do not affect vascular structures, altering their shape at most, while malignant lesions tend to invade these structures until achieving obstruction and thrombosis, this being especially true in case of hepato-cellular carcinomas and metastases; the invasion of these structures can be considered a contraindication for resection, especially when the suprahepatic veins are involved.

If non-segmentary resections are performed, ultrasound can aid delimiting the resection margins, together with those 1-2 cm of healthy surrounding tissue, and when the approach involves local destruction through radioablation, it helps orientate the electrodes and secure the tumoral edges.

In terms of intraoperative ultrasound exam of the pancreas, this can be performed in 2 ways: without surgically exposing the pancreas, transgastrically, using the stomach as an acoustic window, and after exposing the pancreas, through the opening of the gastro-colic ligament, scanning the pancreatic parenchyma directly. Important vascular retropancreatic marks are the portal system along with the confluence of the splenic, inferior and superior mesenteric veins, and as arterial marks the superior mesenteric, gastroduodenal arteries as well as the celiac trunk and its adjacent lymphoganglial tissue; last, but not least, the inferior choledoch and Wirsung duct are visualised.

The pancreatic parenchyma appears as a hyperechogenous structure, clearly superior to that of the liver, but in different degrees in terms of intra- and periglandular fatty infiltration; pancreatic cancers appear as hypoechogenous structures, imprecisely delimited, whose localization, dimensions and degree of vascular invasion must be described. In the case of cystic pancreatic lesions, intraoperative ultrasound allows establishing the density of the fluid and of the intracystic structures, the relationship with neighbouring structures; also, it allows punctures, to establish avascular areas for a possible pericystic-digestive anastomosis, or to identify the Wirsung duct, for a Wirsung-digestive anastomosis. This method is also very useful in identifying neuroendocrine tumoral secreting islets, found mostly in the body and tail, appearing as hypo-echogenous structures, relatively well delimited, usually solid, at the same time allowing the removal of their nuclei under echographic control.

Our study included intraoperative ultrasounds performed with the help of a Esaote MY LAB 20 ultrasound machine, in the operating theatre of the IOB First Surgery Clinic, using a linear amplifier, with frequencies varying between 5.0 MHZ and 10 MHZ, the ultrasound machine being equipped with colour Doppler mode; an amplifier with high frequency and high resolution are necessary. Colour Doppler is very useful in identifying vascular structures and even in differentiating a metastatic lesion from a cyst or a haemangioma. Intraoperative ultrasounds were performed by two surgeons skilled in general echography. (*Fig. 1*)

Indications for intraoperative ultrasound exam in the study group

Transcutaneous abdominal ultrasound is limited in obtaining high quality images, given the presence of the abdominal wall, of the intestinal loops or the colon, that are interposed and act as a screen in front of the ultrasound waves; using intraoperative echography eliminates all these factors. Placing the amplifier directly on the surface of the explored organ allows using high frequency, which leads to a significant improvement of the quality of the obtained images. (*Fig. 2, 3*)

This method has been used as a routine indication in the majority of cases presenting metastases or hepatic tumours, singular or multiple, preoperatively imagistically diagnosed, regardless of the type of initial surgical indication, which

Figure 1. *Essaote MY LAB 20 ultrasound machine with intraoperative probe and puncture kit*

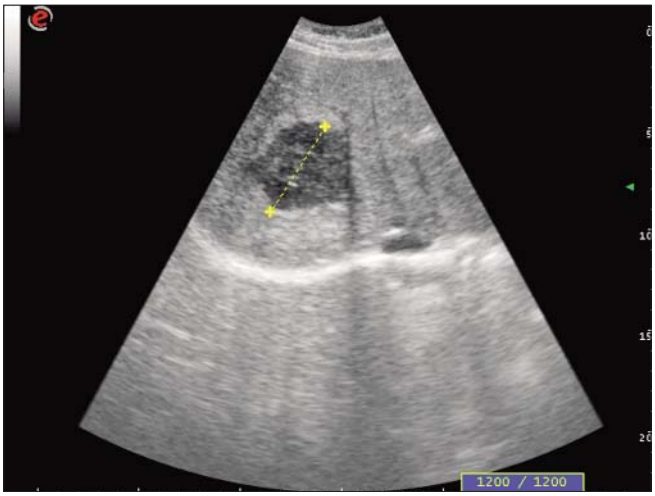

Figure 2. *Preoperative ultrasound – hepatic tumour*

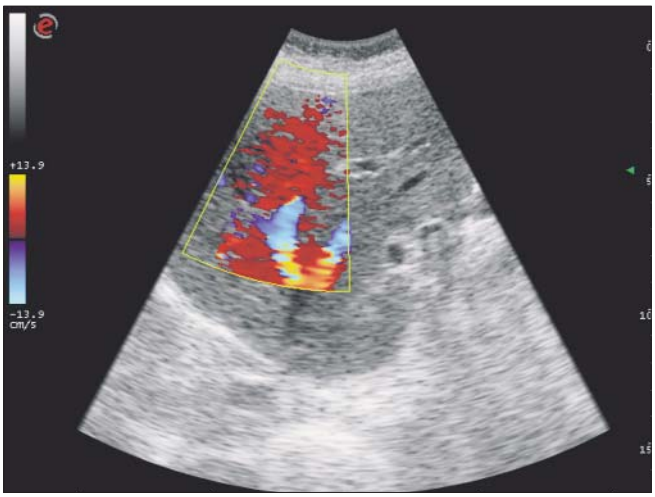

Figure 3. *Preoperative ultrasound - hepatic tumour with high vascularization*

included radioablation destruction or regular or atypical hepatic resection. Intraoperative echography aimed to establish the exact number of hepatic lesions, tracing new elements unidentified by the CT or MRI preoperative exam, and to clearly describe the relationship between the lesions and the biliary vascular elements, in order to establish the resection lines or to guide and control radiofrequency destruction, after reevaluating the intraoperative therapeutic indication.

The benefits of intraoperative echography have been demonstrated in other fields of hepato-bilio-pancreatic pathology, by using this selective indication method in circumstances in which localizing different hepatic (cystic or solid) formations located deep into the parenchyma, inaccessible to palpation or visualization did not allow revealing and puncturing these for biopsy or therapeutic purposes. Also, this method was useful in pancreatic pathology, facilitating the localization of the Wirsung duct with the aim of internal pancreatic drainage or cystic pancreatic tumour localization, aiding the establishment of the optimal puncture or pericystic-digestive drainage area. We have also followed this indication in cases of recto-colic cancers, where preoperative suspicion elements, based on CT or ultrasound scans, of hepatic metastases existed, in order to confirm or infirm these, and determine the real stage of the neoplastic disease. (*Table 1* and *Table 2*)

The patients group on which this study prospective was conducted between 2009-2012 within the IOB First Surgical Clinic consisted in 57 patients with hepato-bilio-pancreatic pathology (37 males and 20 females, aged between 45 and 82 years old, with an average age of 68 years old). Over 87%% of the patients included in the study required oncological treatment, presenting primary and secondary hepatic tumours, and only 7 cases (12.28%) presented with benign pancreatic and hepatic pathology.

The imagistic evaluation protocol included mandatory CT or MRI exam, as well as preoperative echography, whose results were later compared to those of intraoperative echography, focusing mainly on parameters relating to number, size and

Table 1. *Routine indications for intraoperative ultrasound*

Intraoperative Ultrasound – Routine Indication
Hepatic tumours or metastases with indication for radioablation or hepatic resection
Determining new hepatic lesions in patients with metastases shown on CT and MRI scans
Dimensions, localization, relationships with hepatic structures
Evaluating the possibility of resection and marking the resection lines
Guiding and control of radioablation destruction

Table 2. *Selective indications for intraoperative echography*

Intraoperative Ultrasound – Selective Indication
Hepatic Pathology
Localizing solid tumours through hepatic biopsy
Localizing hepatic cysts and abscesses through evacuation and drainage puncture
Determining hepatic metastases in digestive cancers
Pancreatic Pathology
Localizing the Wirsung duct for performing a Wirsung-jejunum derivation
Localizing and morphologically evaluating pancreatic cysts and pseudocysts, for puncturing or performing a pericystic-digestive derivation
Localization, dimensions, relationships between solid pancreatic tumours

structure of the pancreatic and intrahepatic formations, to localization and relationship between elements, to the degree of tumoral vascularization. Biologic parameters, represented primarily by digestive tumoral markers - CEA, CA 19.9, alpha-fetoprotein, as well as data provided by CBC, hepatic and renal biochemistry, and coagulogram were monitored.

In 40 cases (over 70%) ultrasound was performed on patients that presented synchronous or metachronous hepatic metastases, singular or multiple, as part of digestive neoplastic diseases – recto-colic or gastric, where preoperative imagistic investigations indicated either hepatic resection, or radioablation

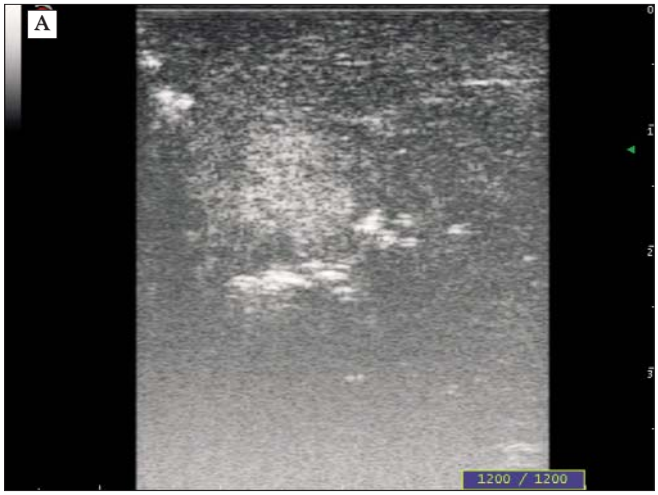

Figure 4. *Intraoperative ultrasound – hepatic tumour during RFA*

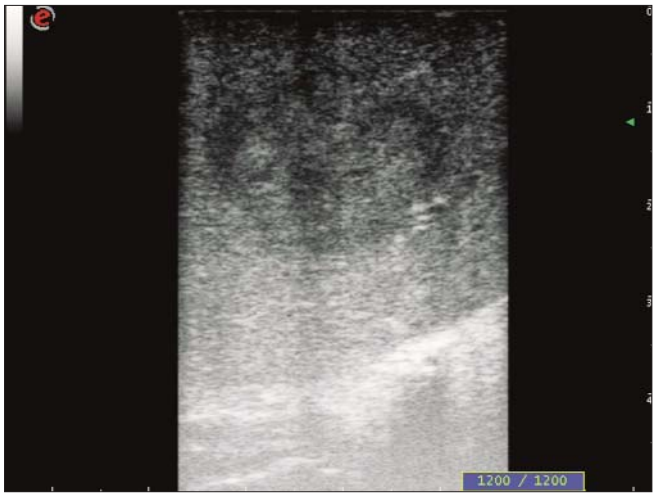

Figure 5. *Intraoperative ultrasound – hepatic tumour*

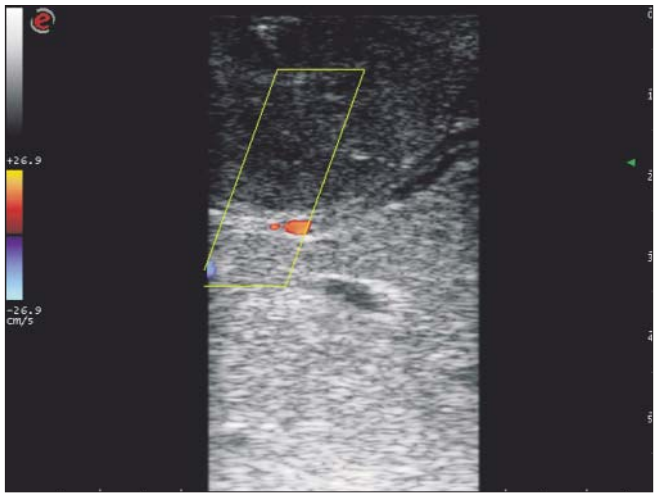

Figure 6. *Intraoperative ultrasound – relations with bilio-vascular structure*

destruction. The number of hepatic determinations varied between 1-5 lesions/per case, with a median of 2 lesions/per case, and their sizes ranged between 0.5-7 cm, with a median of 2.8 cm/per lesion. (*Fig. 4, 5, 6, 7*)

A number of 6 other cases (10.52%) presented hepatic space replacing formations, solid or cystic, benefiting from intraoperative ultrasound control with diagnostic purpose, or that of facilitating surgical procedures; CT imaging suggested hepatic cancer (2 cases), hydatid hepatic cyst developed deep within the parenchyma (1 case), multiple hepatic abscesses (1 case) and 2 cases of singular hepatic lesions whose echographic characteristics and CT scans were not relevant for the particular type of tumour.

Additionally, this method was used in the case of 8 patients (14.03%) with recto-colic cancer, in which hepatic metastases synchronous with the primary tumour, in a variable number of 1-3 determinations were suspected, based on the data provided by ultrasound and CT scans; introoperative examination combined with intraoperative ultrasound and extemporaneous

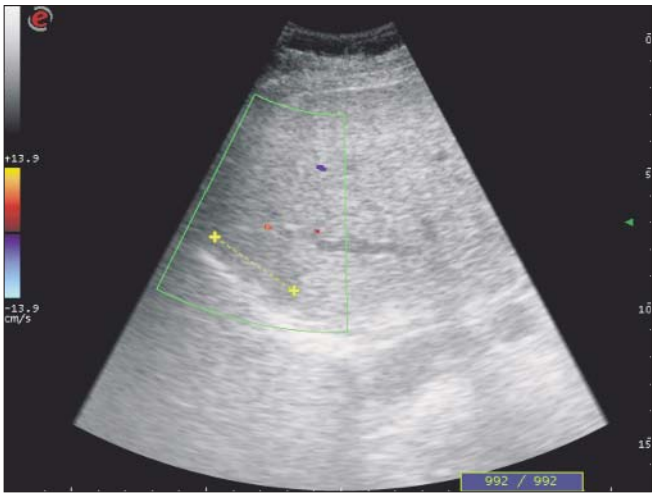

Figure 7. *Postoperative ultrasound at 2 years after RFA of a hepatic tumour without vascularization*

exam were to clearly determine the diagnosis.

Intraoperative ultrasound approach was chosen in 3 cases of pancreatitis (5.26%), complicated by the development of pancreatic pseudocysts with sizes over 8 cm – 2 cases, and 1 case presenting significant distension of the Wirsung duct, associated with major pancreatic pain. The intraoperative aim was to evaluate the global pancreatic structure, to precisely identify the Wirsung duct and to characterize intra- and peri-cystic structures.

Data provided by preoperative imaging techniques were colligated with the information obtained from intraoperative exploration, with perioperative ultrasound descriptions and, finally, with histo-pathologic results, establishing the diagnostic accuracy and value of the method in choosing the therapeutic conduct and in facilitating various surgical procedures.

Results

In the group consisting in 40 patients with hepatic metastases preoperatively documented through imaging, intraoperative ultrasound scan confirmed the presence of metastases in all cases, but in 9 cases (22.5%) it also identified new metastases. The number of additional hepatic determinations varied between 1-3, thus being identified 17 new determinations, with a size constantly measured bellow1.5 cm. The majority of these lesions were located deep in the parenchyma and developed at the level of the Ist, VIIth and VIIIth hepatic segments. Important to be mentioned is that the newly identified lesions could not be evidenced by either preoperative echography, or by CT or MRI exams, the sensitivity of the intraoperative examination being evidently higher. Regarding the specificity of the method, in our records, all lesions identified were histologically confirmed as hepatic metastases.

Beside identifying, localizing and exactly establishing the relationships between the metastases and the bilio-vascular elements, intraoperative echography allowed the precise guidance of the radioablation electrodes, in their sequential applying. The destruction of the entire tumoral mass is thus achieved, both centrally and in the tumour periphery, with the aim of tumour vaporization, through the apparition of gas bubbles surrounding the implanted electrodes, highlighting in real time the radioablation process. Inserting the electrodes under controlled guiding prevents the development of procedural complications related to the injuring of intrahepatic large vessels or of high calible biliary ducts, thus avoiding the development of hematomas, bilomas, biliary fistulas or intrahepatic abscesses. This quality of intraoperative ultrasound was extremely useful, given the fact that over 45% of the hepatic metastases were located deep into the parenchyma, and approximately 20% of these were in intimate relationship with the suprahepatic veins and the intrahepatic Glissonian pedicles. Also, immediate postprocedure echographic control in Doppler colour mode evaluates the peritumoral vascularization, its absence testifying the nearly complete destruction of metastases, as well as the thrombosis of peri- and intratumoral vessels.

In this first group, in 7 cases (17.5%) various hepatic resections were associated with the radioablation of the remaining metastases, the role of ultrasound being that of aiding the intraoperative distinction between a possible additional resection and local destruction. Decisive elements in orienting the surgical strategy towards a local destruction through radioablation, instead of an atypical hepatic resection, were linked to the topography of the determinations, in strict close relationship with the suprahepatic veins or the Glissonian pedicles for neighbouring segments, bearing the major risk of injuring these during the process (which would imply intra- and postoperative complications, such as haemorrhages, biliary fistulas, necrosis and hepatic abscesses), as well as to the volume of remaining parenchyma after complex resection, at the limit of hepatic functionality. The role of echography was to precisely determine these relationships between the bilio-vascular anatomic elements and to evaluate the risks of an atypical resection; additionally, it allowed the safe guided radioablation of these lesions. Other 4 cases (10%) in this group, due to their number and size of metastases exceeded any surgical therapeutic resources, the intervention being limited to diagnostic biopsy, and the remaining 29 cases (72.5%) benefited exclusively from local destruction of metastases through RFA, under ultrasound guidance and control.

In the second group, consisting of 6 patients with hepatic space replacing processes shown on CT scans, the role of intraoperative ultrasound was initially of topographic and structural diagnosis, orienting towards the nature of the lesion (solid or cystic, benign or neoplastic) and focusing on elements regarding homogeneity, the aspect of the parenchyma/tumour interface, the relationship between the bilio-vascular intrahepatic pedicles, the peri-and intratumoral vascularization in Doppler mode. In a first case, intraoperative description of an approximately 7 cm hydatid cyst confirmed by CT , located deep in the parenchyma, at the border between the VII-VIII segments, without expression at the level of the liver capsule and at liver palpation was obtained. After obtaining its localization, impossible otherwise, in the absence of intraoperative ultrasound, the puncturing of the cyst was performed under ultrasound guidance, with the extraction of the proligerous membrane and confirmation of its nature, followed by the fixation of an external drainage; this controlled manner of hydatid cavity drainage is more and more used in surgical services (2). A similar approach was used in the case of a patient with idiopathic hepatic abscesses, developed in the right hepatic lobe, multilocular and partially confluent. Intraoperative ultrasound determined their precise location, with the exclusion of other determinations, offered control over the evacuation of the cavities, aided the fixing of efficient drainages in the areas with a minimum of risk and the controlled destruction of intracavitary fibrous septa, elements that could lead to a relapse. The other four cases were represented by patients with solid hepatic determinations, where preoperative echography, after lesional localization, allowed diagnosis through data regarding the structure of the tumoral formations and by facilitating the biopsy puncture. In two cases, presenting singular hepatic lesions with no relevant

ultrasound and CT characteristics, it suggested a benign nature of the lesions, meaning a 5 cm hepatic adenoma – an encapsulated tumour, solid, well delimited, presenting no invasion in the neighbouring tissue, and a hepatic haemangioma – a well delimited tumour, with high echogenity, easily compressed by the probe. In both situations radioablation was performed. The last remaining 2 cases presented CT scan elements which indicated a high probability of hepatocellular carcinoma, confirmed by the intraoperative ultrasound aspect – a solid, imprecisely delimited mass, highly vascularized and with a high flow in Doppler mode-, and by the extemporaneous biopsy puncture, the surgeries ending with hepatic resection – ultrasound guided segmentomies – and identification of the portal pedicles, suprahepatic veins, and checking of the hepatic section tranche.

In the group of 8 patients with recto-colic cancers, possibly presenting synchronous determinations on preoperative imaging scans, intraoperative ultrasound identified 3 cases of benign lesions – hepatic haemangiomas and regenerative hepatic nodules, confirmed by biopsy puncture, and in the other 5 case certified the presence of metastases, based on imaging and histological criteria. Thus, 11 metastases were found, with sizes ranging from 0.5 to 2 cm, out of these 3 which couldn't be visualized during the preoperative exams. During the same surgical session, beside excision of the recto-colic tumour, either radioablation of metastases or metastasectomy was practiced, both under intraoperative ultrasound guidance. Also, intraoperative ultrasound allowed the correct staging of the neoplastic disease, leading to a choice of post-surgical oncological pathway.

The last group consisted in 3 patients with pancreatic pathology, complicated forms of acute and chronic pancreatitis, with relevant clinical, biochemical and imaging signs. The first step in all 3 cases was ultrasound exploration of the pancreatic parenchyma, after opening the gastro-colic ligament, identifying the possible tumoral masses, followed by a specific lesional approach. In the first case the major clinical sign was represented by severe pancreatic pain, resistant to drug treatment, accompanied by pancreatic insufficiency phenomena, resistant to drug treatment, the CT scan revealing a dilated Wirsung duct; an intervention was performed for a Puestow decompressing pancreatojejunal anastomosis. Localizing the pancreatic duct through minimal dissection is important in order to prevent iatrogenic pancreatitises. Intraoperative ultrasound allowed tracking the Wirsung duct within the scleral calcified pancreatic mass, through an ultrasound guided puncture; clear confirmation was obtained by extracting pancreatic fluid, clear and lacking colour. Afterwards the surgeon made a transversal incision of the pancreatic tissue and duct at this level, followed by a latero-lateral pancreatojejunal anastomosis. The other 2 cases were of patients with outbursts of acute pancreatitis, which developed 6 to 8 weeks afterwards pancreatic pseudocysts of over 8 cm, associated with a septic state. CT exams confirmed the presence of pseudocysts, with inhomogeneous content, developed in the body and tail. Intraoperative ultrasound focused on additional description of the cystic morphology, especially on it content (clear or turbulent), presence/absence of vegetation or intracystic septa, the wall structure and the relationship with the neighbouring elements; thus the puncture and excision of the cysts was performed safely, as well as the pericystojejunal anastomosis in an inferior position, in an avascular area. (*Table 3*)

Discussions

Intraoperative ultrasound has become an important pillar of modern surgery, with diagnostic and therapeutic values, considered now an almost indispensable procedure, especially

Table 3. *Characteristics of the Study Group*

Study Group Characteristics	
Number of patients included in the study	57 cases
Type of lesion	Hepatic metastases (40) - 70.17%
	Hepatic formations (6) – 10.52%
	Recto-colic cancer (8) – 14.03%
	Pancreatitis (3) – 5.26%
Average age of patients included in the study	68 (45-82) years old
Newly determined metastatic hepatic lesions	20(11/48 cases)
Correct colo-rectal cancer staging	8 cases
Congruence hepatic preoperative imaging investigations/ Intraoperative ultrasound	38 /54 cases
Change of therapeutic approach	7/57 cases (12.28%)
Manoeuvres aided by intraoperative ultrasound examination	hepatic biopsy punctures – 19 procedures
	Puncture- hepatic formation drainage – 2 procedures
	Radioablation guidance and control– 43 procedures
	Hepatic resection – 10 procedures
	Identifying the Wirsung duct – 1 procedure
	Pancreatic cyst exploration and guided puncture – 2 procedures

in hepato-bilio-pancreatic surgery (3-8). The main advantage of this method is that it presents in real time the anatomy and structure of the lesion, allowing changes in the therapeutic decision process. It is believed that intraoperative ultrasound exploration determines new hepatic lesions in various percentages, depending on the complexity of preoperative investigations and the type/dimension of the lesion, these percentages varying between 5-30% of the cases (9-12). Thus, in comparison to conventional imaging methods (CT, MRI) intraoperative ultrasound detects 20-30% more hepatic lesions and 10-15% more in comparison to arterioportography CT scan (13). While CT, external ultrasound and MRI scans are limited in identifying hepatic lesions smaller than 2 cm, intraoperative echography, with an excellent spatial resolution and high sensibility detects 3-5 mm solid formations, and 1-3 mm hepatic cysts. As a consequence, the therapeutic plan can be changed according to the data provided by intraoperative ultrasound examination, multiple studies describing therapeutic reorientation, (14-17) in 4.9 - 40% of the cases.

Regarding the detection of new hepatic lesions, undiagnosed by preoperative imaging techniques, our study recorded 20 lesions of this type, in 11 from a number of 48 cases, resulting in a share of 22.91% of completely diagnosed cases. It is to be mentioned that these lesions are of a maximum 1 cm in size, located both deep into the parenchyma and subcapsular, and their identification did not modify the cancer staging, given that they were satellite localizations for other large metastases, confirmed by preoperative imaging. However, a whole treatment was applied, through radioablation of these new localizations or "edge-resection".

Congruence between preoperative hepatic imaging evaluations and intraoperative ultrasound was achieved in 38 of the 54 intraoperative hepatic explorations, the other 16 cases (29.62%) registering significant differences regarding the number of hepatic tumours, their size and their relation to biliary vascular elements, and last but not least, the data regarding lesional structure and vascularization. Determination of the malignant or benign nature of a lesion based on intraoperative echographic criteria in cases with inconclusive preoperative imaging examinations was in full agreement with the histo-pathological result of the extemporaneous biopsy puncture in 12 cases, this method bearing a specificity of 100% in our study group. (*Table 4*)

The value of intraoperative ultrasound is highly supported also by the fact that this exploration determined a change in the intraoperative therapeutic attitude, based on the additional information provided, in 7 cases (12.28%). All cases in which a change was made to the preoperative therapeutic plan, belonged to the first subgroup of patients with imaging confirmed hepatic metastases. Changes were dictated by the topography of the determinations in 3 cases, in which atypical resection was the initial aim, afterwards however combined with radioablation, as a result of the close relation of the lesion to the suprahepatic veins or to the Glissonian pedicles of the neighbouring segments, with a major risk of injuring these latter structures during the excision (which would have led to intra- and postoperative complications). In the other 4 cases the aim was a regulated hepatectomy, but due to the metastatic dissemination in the contralateral liver lobe, shown only by the intraoperative ultrasound, the laparotomy ended in just a reductional radioablation, with palliative purposes.

Routine protocol in the case of patients with digestive cancers, intraoperative hepatic ultrasound, by determining lesions smaller than 1 cm which were not visible on preoperative imaging scans, obtain a correct staging of the neoplastic disease and aid in establishing the correct onco-therapeutical postoperative plan. Given the fact that 20-25% of the patients with colo-rectal cancer present hepatic metastases at the time of the surgical intervention, and occult hepatic metastases are present in approximately 10-30% of cases 16, intraoperative ultrasound examination is recommended whenever available, as it brings additional information, completing the surgical gesture or excluding associated pathologies, improving the therapeutic management of patients.

Intraoperative ultrasound can be performed by an ultrasound exam specialist who is familiar with an operating room, but in our opinion a surgeon specialized in echography as well can obtain that information that can bring a maximum of efficiency to the surgical intervention, similar to the situation in great European hepato-bilio-pancreatic surgery centres.

Table 4. *Intraoperative ultrasound in determining the nature of the hepatic lesion*

Intraoperative Ultrasound – Criteria for Benign/Malignant Lesion Evaluation	
Benign Lesions	
Hepatic adenoma	Encapsulated tumour, solid, well delimited, no invasion in the adjacent parenchyma
	Benign lesions usually leave vascular structures intact, modifying their shape at most
Hepatic haemangioma	Well delimited tumour, with high echogenity, easy compressed by the probe
Malignant Lesions	
Hepatocellular carcinoma	Solid mass, imprecisely delimited, with heterogeneous structure and rich vascularization, and high flow in Doppler mode
Hepatic metastases	Colo-rectal cancer metastases are usually hypoechogeneous, with or without calcifications, with a tendency of invading vascular structure until their obstruction and thrombosis

Conclusions

Intraoperative ultrasound is an extremely useful tool in the diagnosis and surgical treatment of various lesions of the hepato-bilio-pancreatic tract. It proves itself to be a harmless method, simple and easy, unirradiant, with the quality of being repetitive and accessible to routine performance without amplifying the strain of the intervention or significantly increasing its duration. Intraoperative ultrasound replaces palpatory examination where it is not possible to be performed, guides various diagnostic and therapeutic procedures, assisting the surgeon in accurately performing certain operative techniques, lowering the risk rate for intra- and postoperative complications. It enables a complete and correct diagnosis, with a truthful staging, and aids in establishing the adequate therapeutic attitude. In our opinion, intraoperative ultrasound, with all its above-mentioned characteristics, is an important element, necessary for routine practice, in the diagnostic and therapeutic algorithm of the hepato-bilio-pancreatic pathology.

References

1. Machi J, Sigel B, Zaren HA, Kurohiji T, Yamashita Y. Operative ultrasonography during hepatobiliary and pancreatic surgery. World J Surg. 1993;17(5):640-5; discussion 645-6.
2. Botea F, Sârbu V, Dima S, Iusuf T, Unc O, Toldişan D, et al. The role of intraoperative ultrasound in the diagnosis and treatment of hydatid liver disease. Revista Chirurgia (Bucur). 2006;101(6): 593-8. Romanian
3. Makuuchi M, Hasegawa H, Yamazaki S. Intraoperative ultrasonic examination for hepatectomy. Ultrasound Med Biol. 1983;Suppl 2:493-7.
4. Gozzetti G, Mazziotti A, Bolondi L, Cavallari A, Grigioni W, Casanova P, et al. Intraoperative ultrasonography in surgery for liver tumors. Surgery. 1986;99(5):523-30.
5. Makuuchi M, Torzilli G, Machi J. History of intraoperative ultrasound. Ultrasound Med Biol. 1998;24(9):1229-42.
6. Cociorvei A, Calu V. Laparoscopic ultrasound in biliary diseases. Chirurgia (Bucur). 2011;106(3):353-8. Romanian
7. Popescu I, Ionescu M, Alexandrescu S, Ciurea S, Hrehoreț D, Sârbu-Boeți P, et al. Surgical treatment of liver metastases from colorectal cancer. Chirurgia (Bucur). 2006;101(1):13-24. Romanian
8. Crețu D, Sabău A, Dumitra A, Sabău D. Role of early biliary and pancreatic decompression by minimally invasive procedure in acute pancreatitis. Chirurgia (Bucur). 2012;107(2):180-5. Romanian
9. Takigawa Y, Sugawara Y, Yamamoto J, Shimada K, Yamasaki S, Kosuge T, et al. New lesions detected by intraoperative ultrasound during liver resection for hepatocellular carcinoma. Ultrasound Med Biol. 2001;27(2):151-6.
10. Torzilli G, Makuuchi M. Intraoperative ultrasonography in liver cancer. Surg Oncol Clin N Am. 2003;12(1):91-103.
11. Cerwenka H, Raith J, Bacher H, Werkgartner G, el-Shabrawi A, Kornprat P, et al. Is intraoperative ultrasonography during partial hepatectomy still necessary in the age of magnetic resonance imaging? Hepatogastroenterology. 2003;50(53):1539-41.
12. Zhang K, Kokudo N, Hasegawa K, Arita J, Tang W, Aoki T, et al. Detection of new tumors by intraoperative ultrasonography during repeated hepatic resections for hepatocellular carcinoma. Arch Surg. 2007 Dec;142(12):1170-5; discussion 1176.
13. Soyer P, Levesque M, Elias D, Zeitoun G, Roche A. Dtection of liver metastasis from colorectal cancer comparison of IOUS and CT during arterial portography. Radiology. 1992;183(2): 541-4.
14. Parker GA, Lawrence W Jr, Horsley JS 3rd, Neifeld JP, Cook D, Walsh J, et al. Intraoperative ultrasound of the liver affect operation decision making. Ann Surg. 1989;209(5):569-76; discussion 576-7.
15. Solomon MJ, Stephen MS, Gallinger S, White GF. Does intraoperative hepatic ultrasonography change surgical decision making during liver resection? Am J Surg. 1994;168(4):307-10.
16. Kane RA, Hughes LA, Cua EJ, Steele GD, Jenkins RL, Cady B. The impact of intraoperative ultrasonography on surgery for liver neoplasms. J Ultrasound Med. 1994;13(1):1-6.
17. Luck AJ, Maddern GJ. Intraoperative abdominal ultrasonography. Br J Surg. 1999;86(1):5-16.