Liver Biopsy

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Contents

Liver biopsy is considered nowadays the most reliable tool to diagnose diffuse hepatic disease, despite improvements in serological and radiological techniques. The indications for this invasive technique must be weighed against the small, but not negligible, risk of complications (Tannapfel et al. 2012).

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The diagnostic accuracy of liver biopsy encloses several factors, e.g. patient cooperation, operator skills and experience, use of image guidance or assistance, biopsy technique, needle gauge, type of needle, number of biopsy passes, nature of the underlying histology and lesion size (Szymczak et al. 2012).

Nowadays liver biopsy might be taken percutaneously (via a needle through the skin or with an endoluminal biliary biopsy during percutaneous transhepatic biliary drainage) and transvenously (through the blood vessels).

1 Percutaneous Liver Biopsy

1.1 Historical Background

Paul Ehrlich is credited with the first liver aspiration in 1883 and subsequently the first percutaneous liver biopsy for diagnostic purposes was reported in 1923 (Bingel 1923). The technique has been modified since then, and over the past 50 years it has become a central investigation of hepatic disease. The low mortality (0.01–0.17%) and the relatively low morbidity of this procedure have meant that liver biopsy has become widely used (Sherlock and Dooley 1997).

1.2 Introduction

Correct diagnosis of hepatic lesions has a fundamental importance in oncology as it allows patients with malignant lesions to undergo the most appropriate treatment and those with benign lesions to avoid surgical interventions. Despite improvements in serological and radiological techniques, currently liver biopsy remains the most reliable method to obtain a suspicious lesion sample and a correct diagnosis (Bravo et al. 2001; Dezsofi and Knisely 2014; Myers et al. 2008; Rockey et al. 2009).

Percutaneous liver biopsy is a safe and effective invasive procedure, provided that the indications, contraindications, risk factors for complications and failure are considered carefully (El-Shabrawi et al. 2012; Holtz et al. 1993; Matos et al. 2012; Mogahed et al. 2016; Ozawa et al. 1994; Potter et al. 2011; Sparchez 2005; Westheim et al. 2012).

There are a number of variables within the literature that influence the diagnostic adequacy and accuracy of liver biopsy that include patient cooperation and body habitus, operator grade and experience (Szymczak et al. 2012), use of image guidance or assistance, biopsy technique, needle gauge, type of needle, number of biopsy samples, nature of the underlying histology and lesion size (Howlett et al. 2012).

US is the first choice for the guidance of percutaneous biopsy of hepatic lesions, to reduce the risk of complications (Kader et al. 2003).

US has a lot of advantages, including real-time capability, absence of radiation hazard, easy accessibility and low cost. But on the other hand, US cannot recognize all focal hepatic lesions.

1.3 Patient Selection

Not all patients with liver injury may undergo a percutaneous liver biopsy. Patients must be evaluated to recognize who can be submitted to the procedure (indications, alternative methods).

Radiologist should know the medical history of a patient and previous imaging studies (Lee et al. 2012; Veltri et al. 2017).

Then, it is necessary to check the patient's medications and suspend any anticoagulant/antiplatelet medications (Aspirin/Plavix discontinued 7–10 days prior and resumed 48–72 h post-procedure; warfarin discontinued 5–7 days prior and resumed the day following the procedure; heparin should be withheld 6–12 h prior to the procedure) (Gopal et al. 2011).

If the patient has any type of coagulation anomalies, these must be corrected (e.g. low platelet count, INR, PT, APTT, chronic renal failure, haemodialysis) (Douketis et al. 2012;

Hinojar et al. 2015; Patel et al. 2012; Rockey et al. 2009; Scheimann et al. 2000; Veltri et al. 2017).

Patients with cardiovascular issues (coronary stents, prosthetic valves) should be evaluated by a cardiologist, to be able to suspend therapy safely (Gopal et al. 2011).

1.4 Contraindications

Even though image-guided percutaneous liver biopsy is a relatively non-invasive procedure, there are defined absolute and relative contraindications (Bravo et al. 2001; Gopal et al. 2011; Rockey et al. 2009). The first ones prohibit the procedure, and the second ones allow it to be performed (Figs. 1, 2, 3, 4, 5 and 6).

Identifying contraindications is important to avoid the major complications associated with the procedure (Mogahed et al. 2016).

The relative contraindications include all those conditions that increase the risk of complications. They should be promptly recognized and, when possible, corrected. They include the inability of the patient to cooperate (in this case general anaesthesia may be considered), coagulopathies, use of antiplatelet/anticoagulant drugs within 7–10 days (e.g. coumadin), presence of ascites (if difficult to reach the liver, the solution is to precede the biopsy with a paracentesis), obesity, known focal hepatic lesions (with histological

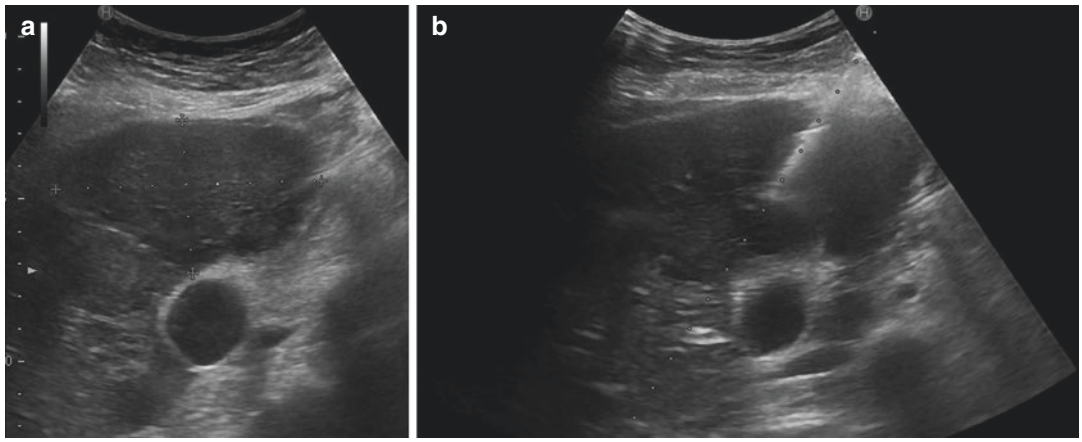

Fig. 1 Percutaneous biopsy of a lesion in the left lobe of the liver. (**a**) Pre-biopsy observation; (**b**) biopsy of the lesion with evidence of needle tracking

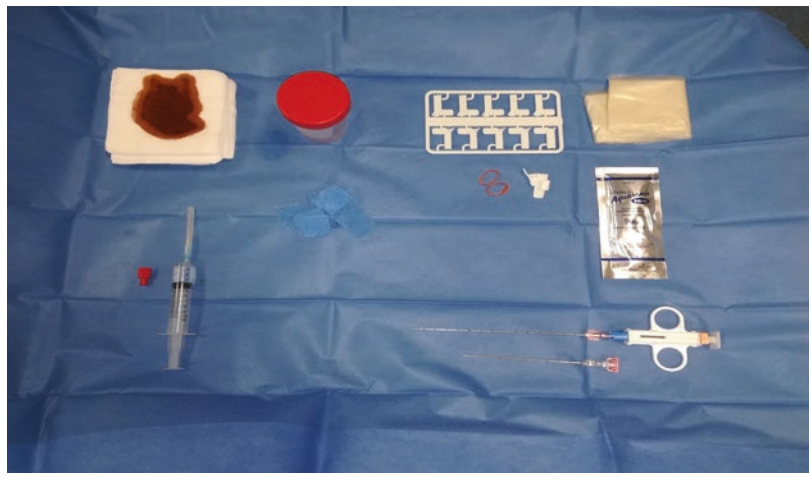

Fig. 2 Percutaneous liver biopsy materials: iodine solution, lidocaine hydrochloride 2%, formaldehyde solution, guide brackets, sterile probe cover and sterile ultrasound gel, 18G side-cutting biopsy needle

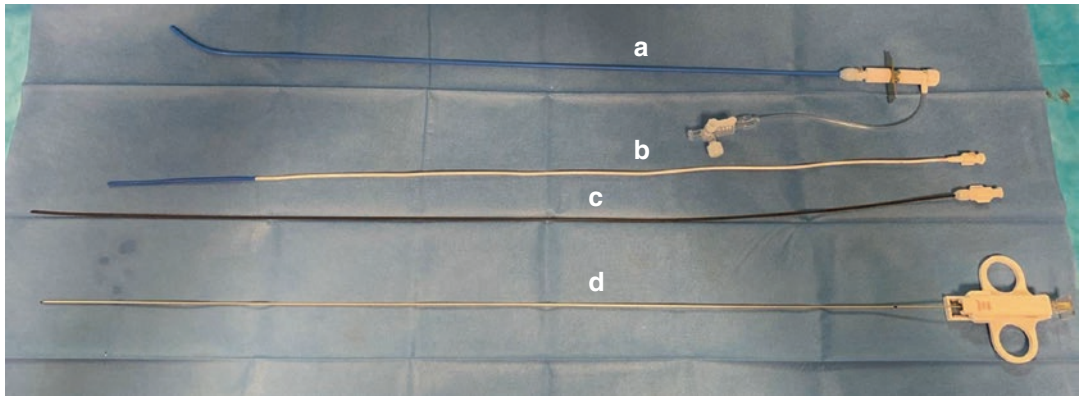

Fig. 3 Semi-automatic transjugular liver biopsy system: The four different parts from top to bottom are (**a**) the blue 7-French curved-ended sheathing catheter equipped with its antireflux valve, (**b**) the white 5-French end-hole straight catheter used to facilitate introduction of the sheathing catheter, (**c**) the black 5-French end-hole catheter which will be coaxially inserted into the sheathing catheter before descending on a stiff metal guide wire and (**d**) the biopsy needle in the "armed" position

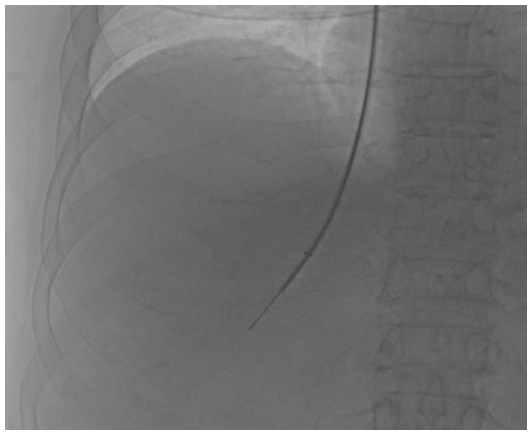

Fig. 4 Transjugular liver biopsy: Tru-Cut technique. The sheathing catheter is within the right hepatic vein and the needle moves forward in the hepatic parenchyma

diagnosis), vascular anomalies, bacterial cholangitis, unavailability of blood products for transfusion and premature infant.

Absolute contraindications are rare and include uncorrected severe coagulopathy (prothrombin time 3–5 s more than control, platelet count <50,000/mm, INR >1.5, prolonged bleeding time >10 min, factor VIII or IX deficiency, von Willebrand disease, hereditary bleeding disorders, sickle cell anaemia), intrahepatic abscess, history of unexplained bleeding (e.g. hyperfibrinolysis), hepatic infection, extrahepatic biliary obstruction, hydatid cyst (it causes anaphylaxis), lack of a safe access and refusal of consent.

1.5 Patient Preparation

The first step before performing a percutaneous liver biopsy is to obtain the informed consent by the patient (Scheimann et al. 2000; Veltri et al. 2017).

On the day of procedure, the patient must be fasting. Basal vital signs (blood pressure, heart rate, respiratory rate) and O_2 saturation are monitored (Davignon et al. 1979; Eachempati 2013; Fleming et al. 2011; Horan et al. 1987; Park 1996). An intravenous access is taken (Gopal et al. 2011).

Uncooperative patients (e.g. children) require sedation and the biopsy procedure is performed in an OR.

1.6 Procedure

A supine position is required with the right hand of the patient comfortably resting behind the head. In case of multiple hepatic lesions, it is necessary to recognize the target lesion (accessibility). A preliminary US exam is performed before the procedure to localize the lesion and a proper

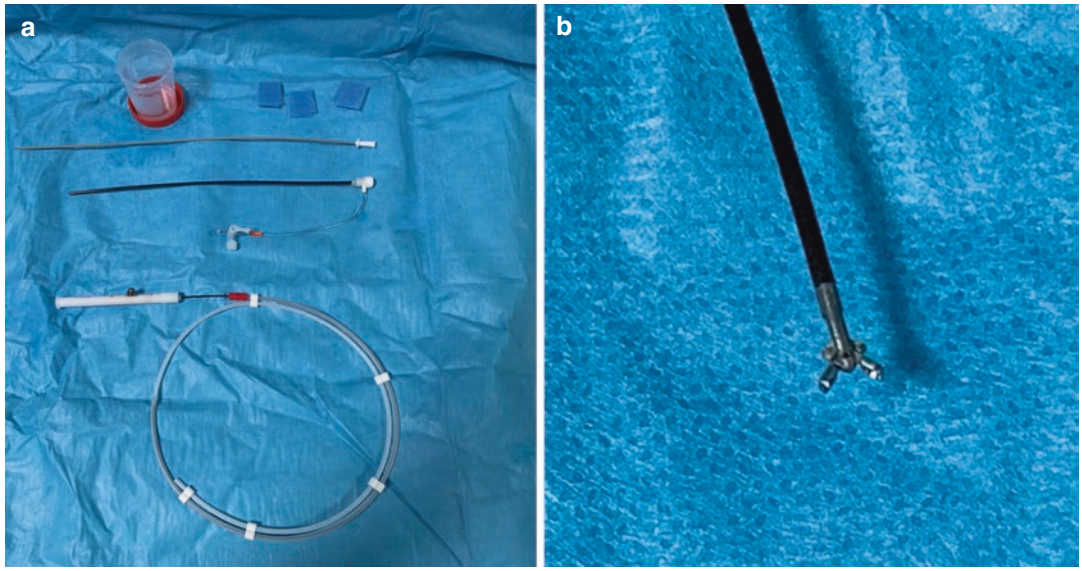

Fig. 5 Percutaneous Transhepatic Cholangio-Biopsy forceps device. (**a**) Materials; (**b**) detail of the forceps tail

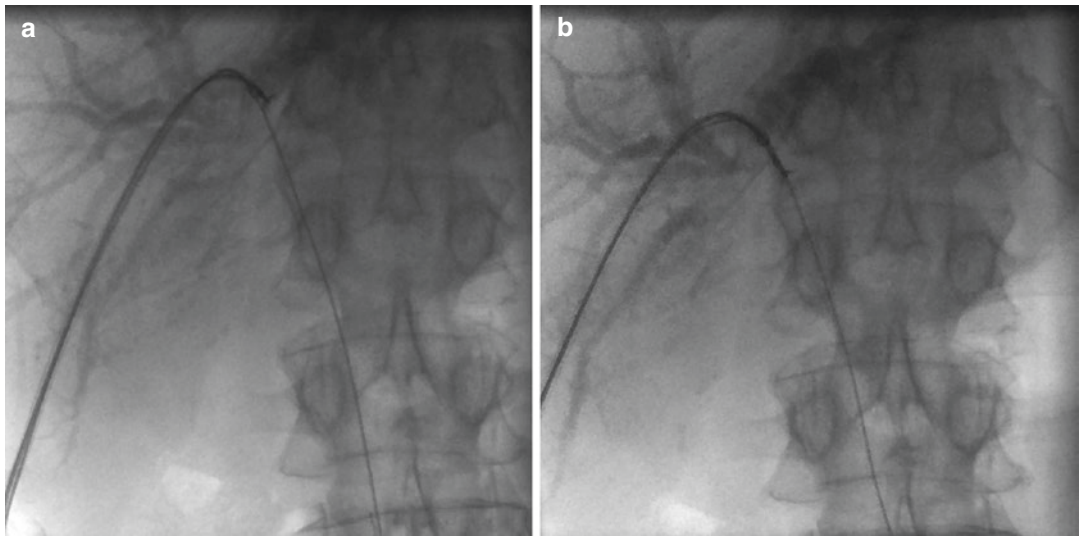

Fig. 6 Percutaneous Transhepatic Cholangio-Biopsy procedure. The biopsy forceps device is inserted using a guide wire, positioned over the biliary obstruction, (**a**) and then is pushed open within the tissue (**b**)

site for the biopsy (away from gallbladder, large vessels or bile ducts, lung, kidney—Fig 1a); a mark is made on the patient's skin (Mogahed et al. 2016; Veltri et al. 2017; Al Knawy and Shiffman 2007; McGrath and Sabharwal 2011).

The biopsy site is sterilized using iodine solution (for patients with iodine allergy, using Citroclorex 2%). Asepsis is required; the operator uses a sterile pack to cover the region of interest and a sterile probe cover with a sterile adapter.

Before biopsy, it is necessary to use a local anaesthetic with lidocaine hydrochloride 2%, injected between the skin and the hepatic capsule (for children, lidocaine 1%). It is important to ensure that anaesthetic is not injected into a vascular structure (Rockey et al. 2009; Mogahed

et al. 2016; Veltri et al. 2017; McGrath and Sabharwal 2011; Lorentzen et al. 2015).

Patient must be collaborative; in particular he/she has to hold his breath during procedure. In patients who have difficulty complying with breath holding, they may be allowed to breathe once the needle tip is deep into the liver capsular surface (Gopal et al. 2011).

Biopsy is performed using an 18G side-cutting biopsy needle and by tracking needle penetration on US (Fig. 1b). US confirms the achievement of the tissue core and the absence of immediate complications. In case of failure or inadequate sample, biopsy can be repeated, but in the eventuality of repeated unsuccessful attempts, the biopsy can be reprogrammed another day (Howlett et al. 2012). The sample is quickly placed in a formaldehyde solution and sent to the histological analyses.

To prevent and recognize the complications, an US scan post-procedure is useful.

1.7 Post-procedure

Patient is kept in for rest and monitored for 6 h after the biopsy (basal vital signs and O_2 saturation). Only conscious patients can eat. A dosage of haemoglobin after the procedure can control and prevent the anaemia; in patients with haemoglobin level drop and hypotension, a transfusion is required. In case of pain, analgesics can be administered to the patient. Rest from lifting heavy weights and physical activity is recommended for 48 h post-procedure (Mogahed et al. 2016; Gopal et al. 2011).

1.8 Materials and Devices

The liver biopsy devices (Fig. 2) used most are the core-aspiration needles (Menghini, Jamshidi or Klatskin style) and sheathed cutting needles (either manual or spring loaded, often referred to as a "Tru-Cut style" in reference to one of the earliest cutting devices).

The cutting needle devices pass into the hepatic parenchyma using a troughed needle before an outer sheath or hood slides over this to secure a core of tissue. The calibre of (most) current cutting needles is about 18 gauge. Conversely, the traditional core-aspiration technique relies on suction generated via a syringe in conjunction with a flat or a bevelled (Menghini or Klatskin) needle tip. Newer automated core needle devices have recently emerged; these utilize a tiny inflection of the cannula at its tip, which serves to trap the specimen and obviates the need for suction (Howlett et al. 2012).

To avoid multiple steps through the liver parenchyma, increasing the risk of bleeding, it is very common to use a needle with Chiba tip, equipped with cannula with Chiba and internal chuck.

The radiologist can place the Chiba needle and through it, he/she can take several samples of the lesion to be analysed.

1.9 Complications

In only 13% of cases patients develop complications after the procedure (Bravo et al. 2001; Rockey et al. 2009; Veltri et al. 2017; Gopal et al. 2011; Howlett et al. 2013). Liver cirrhosis, malignancy, advanced age, impaired coagulation and number of passes are risk factors for serious complications in adults (McGill et al. 1990; Wawrzynowicz-Syczewska et al. 2002).

The biopsy complications are divided into major and minor (Cadranel et al. 2000; Neuberger et al. 2004; Pawa et al. 2007; Perrault et al. 1978; Stone and Mayberry 1996).

Major complications are bleeding in the peritoneal cavity (within 2 h after procedure, the symptoms are hypotension and tachycardia), due to a penetration in a branch of artery or portal vein (Atwell et al. 2010); biliary peritonitis or pleuritis (after a puncture of a bile duct or gallbladder perforation); haemobilia (GU bleeding, biliary pain and jaundice); intrahepatic hematoma; haemothorax; bacteraemia, septicaemia; shock; and death (1:10,000).

Minor complications are pain (84% patients); vasovagal reactions (mild transient hypotension); intrahepatic or subcapsular haematomas (often asymptomatic); pancreatitis after biopsy of an echinococcal cyst; puncture of adjacent abdominal

organs; pneumothorax; pneumoperitoneum; pneumoscrotum; subcutaneous emphysema; subphrenic abscess; infection; and breaking of biopsy needle.

2 Transjugular Liver Biopsy

2.1 Introduction

In most patients, percutaneous biopsy is the preferred method to obtain hepatic tissue for its simplicity, ease and safety.

However, there are conditions, such as ascites and haemostatic defect, where percutaneous access is contraindicated because it is associated with a high risk of haemoperitoneum, which can be life threatening (Tobkes and Nord 1995).

In these cases, transjugular biopsy of the liver has become an accepted alternative method to obtain liver tissue specimens (Rosch et al. 1973) and it is generally considered effective, safe and well tolerated and major complications are extremely rare (Dohan et al. 2015).

2.2 Indications

Severe coagulation disorder and moderate or severe ascites resulting from advanced chronic liver disease or fulminant hepatic failure are the commonest indications for transjugular liver biopsy (McAfee et al. 1992).

In particular, transjugular liver biopsy can be performed in early acute liver failure for diagnostic, prognostic or therapeutic purpose, for example in acute alcoholic hepatitis, due to the need for specific corticosteroid treatment and the frequency of haemostatic disorders (Donaldson et al. 1993; Rockey et al. 2009).

In fact, liver biopsy via the venous system is performed without penetrating the liver capsule, and consequently it reduces the risk of bleeding (Rosch et al. 1973; Tobkes and Nord 1995).

Biopsy via the intravenous system is also chosen when additional procedures such as the measurement of the hepatic venous pressure gradient are required as part of the diagnostic evaluation, so that it is possible to perform both procedures through the same jugular access (McAfee et al. 1992).

Other less common reasons for using a transjugular approach to liver biopsy include previously failed percutaneous liver biopsy; a small, hard, cirrhotic liver; obesity with a difficult-to-identify flank site; and comorbidities that could lead to excessive bleeding during percutaneous biopsy (i.e. suspected vascular tumour, haemodialysis and chronic renal insufficiency or peliosis) (McAfee et al. 1992; Rockey et al. 2009).

Finally, transjugular liver biopsy can be an option in selected focal liver lesion, especially in case of previous failed percutaneous biopsy. In this circumstance, it is necessary to use ultrasound (US) or computed tomographic (CT) guidance for obtaining needle biopsy specimens (Ble et al. 2014).

2.3 Contraindications

There is no specific contraindication for transjugular liver biopsy, and for each patient risks and benefits should be considered (Ble et al. 2014).

The main limits are thrombosis of the right internal jugular vein or inability to access it.

Although, in this case, there are other possibilities to perform the venous access, such as via the right external jugular vein, the left internal jugular vein or the femoral vein, these should be the final chance, because they are riskier than the conventional route (Yavuz et al. 2007).

Another limit for transjugular liver biopsy is hepatic venous occlusion; in such cases some authors have described the transcaval biopsy technique as a proven, safe and viable option for obtaining liver samples (Mammen et al. 2008).

Other contraindications for transjugular liver biopsy described in literature are hydatid cysts, cholangitis and thrombosis of the hepatic veins (Dohan et al. 2014).

2.4 Patient Preparation

Patient should be informed about the technique and its risks; he/she must have fasted for at least 6 h and a written informed consent should be obtained. Moreover, clotting studies, serum

creatinine and an adequate management of anticoagulant therapy are required before the exam.

There is no consensus regarding the need for antibiotic prophylaxis and it should be managed on a case-by-case basis. The transjugular liver biopsy is performed in an interventional radiology room, under strictly aseptic conditions, and patient's vital signs (blood pressure, oxygen saturation, electrocardiographic parameters and heart rate) are monitored during the procedure. A peripheral venous access should be placed, and oxygen may be administered via a nasal cannula.

Light conscious sedation with benzodiazepines may be employed to relieve anxiety and minor discomfort (in particular, midazolam does not influence hepatic haemodynamics), while general anaesthesia is necessary for uncooperative and paediatric patients.

2.5 Procedure

The patient is positioned supine, with the head slightly turned in the opposite direction of the puncture site (preferentially right internal jugular vein).

Previous US evaluation gives precise information of topographic location of the right internal jugular vein and confirms its permeability; if this access is not feasible, left internal jugular, external jugular, subclavian or even femoral vein can be used (Ble et al. 2014; Dohan et al. 2014; Kalambokis et al. 2007).

After skin disinfection, positioning of a sterile drop and subcutaneous local anaesthetic infiltration, under ultrasonographic guidance, the right internal jugular vein is punctured using an 18-gauge needle connected to a saline-filled syringe.

Under fluoroscopic control, a 0.035-in. J-tipped guidewire is inserted into the vein and a 9–10 French (11 cm long) introducer is passed through according to Seldinger technique over the guide wire.

A 5-French end-hole catheter and a J-tipped 0.035-in. flexible hydrophilic guide are launched through the introducer via the superior vena cava, right atrium, inferior vena cava and right hepatic vein or an appropriate alternative hepatic vein and a hepatic venogram is obtained to confirm the correct position of the catheter (3–4 cm from the inferior vena cava). Hepatic venous pressure gradient (HVPG) can be measured at this point. Once hepatic venous pressure gradient is measured, the catheter for the biopsy should be placed.

The specimens could be obtained by Menghini technique (aspiration system, using Colapinto needle) or Tru-Cut technique (cutting system) (Figs. 3 and 4).

Menghini technique: A 9-French tetrafluoroethylene (TFE) sheath catheter with curved tip is positioned into the hepatic vein and then the Colapinto needle is advanced into the sheath until it reaches the hepatic vein and successively is moved forward 1–2 cm into the liver parenchyma, with the patient holding his/her breath. To perform the puncture, a syringe is attached to the edge of the needle and aspiration force should be applied while puncturing.

Tru-Cut technique: A 7-French curved-end sheathing catheter is introduced into the hepatic vein and the sampling system is introduced coaxially to carry out the biopsy.

The direction of the needle tip is based on the hepatic vein selected: anteriorly if the right hepatic vein is catheterized or posteriorly if the median vein is catheterized. Biopsy through the left hepatic vein is used less because of a higher risk of extracapsular puncture due to lower left lobe dimensions. The starting point of the biopsy should be at 3–4 cm from the hepatic vein. It is important to remember that the semi-automatic sampling system moves forward for at least 24 mm and because of this the procedure should be checked regularly to ensure that the distal end of the biopsy needle is not too close to the liver capsule to reduce the risk of capsular rupture or bleeding. Moreover, after each pass, contrast medium should be injected to detect possible contrast leak.

If the liver specimen is absent or inadequate, other attempts may be made until success is achieved. It is recommended to take three biopsy samples, but two samples seem to be sufficient

(depending on the size of the first two samples and their degrees of fragmentation).

There are no specific indications about post-operative care of these patients; however the authors recommend to monitor patient's vital signs for the next 2–4 h. Additionally if the capsule has been punctured the patient should be observed closely for at least 12 h.

In case of increased right upper quadrant pain, dyspnoea or vital sign change, it is mandatory to perform further exams and appropriate explorations to detect potential complications.

2.6 Complications

The total rate of complications in a systematic review of 62 series was 7.1%, divided into minor complications (6.5%), major complications (0.5%) and death (0.09%) (Kalambokis et al. 2007).

According to the Society of Interventional Radiology, minor complications are transitory abdominal pain, capsule perforation without haemodynamic effect, pyrexia, limited intrahepatic haematoma and other very exceptional complications such as a biliary fistula, or hepatic artery aneurysm. Other minor complications related to the puncture of the internal jugular vein such as neck pain, haematoma in the neck, accidental puncture of the carotid artery and even pneumothorax are much rarer when US guidance is used.

Major complications (Dohan et al. 2014, 2015) consist of haemoperitoneum, large hepatic haematoma, ventricular arrhythmia, pneumothorax, inferior vena cava or renal vein perforation and respiratory arrest. Death occurs almost exclusively due to hemoperitoneum and ventricular arrhythmia.

3 Percutaneous Transhepatic Cholangio-Biopsy (PTCB)

3.1 Introduction

Tumours affecting the biliary system, despite the recent advances in diagnostic imaging, are often too small to have specific imaging findings to allow the differentiation between the malignant structures from benign ones (Ierardi et al. 2014). In these cases, tissue sampling becomes essential to diagnose the real nature of the obstruction; according to the current European Society for Medical Oncology (ESMO) guidelines, histological confirmation is mandatory before any non-surgical treatment such as chemotherapy, radiation therapy and biliary stenting (Valle et al. 2016). Percutaneous FNAB with US or CT guidance is often unsuccessful in biliary tumours (Jung et al. 2002).

Endoluminal techniques used for obtaining biliary samples can be shortly divided into those that require a percutaneous or an endoscopic access tract. Percutaneous-based methods include percutaneous transhepatic cholangiography (PTC), brush cytology, and cholangioscopy, while endoscopy-based methods include endoscopic retrograde cholangiopancreatography (ERCP) and endoscopic ultrasound (EUS). When accessing the biliary tree using ERCP- and PTC-based methods, either washings or brushings can be taken and sent for cytology (Patel et al. 2015).

Cytological sampling performed during percutaneous transhepatic biliary drainage (PTBD) or endoscopic retrograde cholangiopancreatography (ERCP) has been proven to be safe and popular (Ierardi et al. 2014) and represents the most commonly used technique since it is relatively simple and requires little time, but offers insufficient sensitivity of 30–60% (Kulaksiz et al. 2011; Selvaggi 2004; Rossi et al. 2004; Volmar et al. 2006).

PTBD is today considered a well-established, non-surgical method of relieving obstructive jaundice; collection of bile for cytologic examination is easy but often non-diagnostic (Jung et al. 2002). Endoluminal biliary biopsy during PTBD has been first reported almost 40 years ago (Elyaderani and Gabriele 1980) and several studies have described the safety and efficacy of the method using different forceps sets (Inchingolo et al. 2018; Andrade et al. 2017; Li et al. 2014, 2016; Park et al. 2017). The transluminal approach offers a direct and accurate route for the biopsy of biliary tumours, and a specimen can be

obtained from a region that appears abnormal on a cholangiogram even when the tumour responsible for the stricture is not clearly visible at CT or at US. Forceps biopsy also enables the acquisition of deeper samples than does brush cytology. Forceps biopsy procedures were reported during PTBD to have greater accuracy and sensitivity (80–90%), with a specificity of 100% (Ierardi et al. 2014; Jung et al. 2002); this technique, however, has shown a poor negative predictive value.

PTCB is usually performed to diagnose the nature of a biliary obstruction. The lesions responsible for this obstruction, in most cases, are cholangiocarcinoma, HCC, fibrous tissue from chronic inflammation of the bile duct, metastatic lymph nodes or masses that compress the bile duct, and metastatic invasion of the biliary tree. Most of the studies on this technique show that the sensitivity of forceps biopsy with malignant tumours other than cholangiocarcinoma is lower that its sensitivity in patients with cholangiocarcinoma, so we can say that cancer originating in the biliary system is the best indication for PTBC (Jung et al. 2002; Li et al. 2016).

3.2 Contraindications

No absolute contraindications to the procedure are reported in literature.

Relative contraindications are, more or less, the same of the other interventional procedures on the liver and biliary tract that are sepsis, cholangitis, coagulopathy and allergy to iodinated contrast; in addition, large ascites can displace the liver from the abdominal wall, increasing the technical difficulty of percutaneous intervention.

3.3 Procedure

Usually the procedure is performed during conscious sedation (Jung et al. 2002) and under local anaesthesia at the puncture site (Inchingolo et al. 2018). Some authors (Ierardi et al. 2014; Andrade et al. 2017; Jung et al. 2002) recommend the administration of broad-spectrum antibiotics for both the drainage and the biopsy procedures. Heart rate, electrocardiographic trace, oxygen saturation, respiratory frequency and blood pressure are usually monitored throughout the procedure (Ierardi et al. 2014).

PTCB can be performed during the placement of the biliary drainage or some days after, for alleviation of cholangitis and haemobilia (Andrade et al. 2017; Jung et al. 2002).

Following percutaneous transhepatic access, a cholangiography has to be performed to identify the site of the obstruction. Then, under fluoroscopic guidance, the biliary obstruction is negotiated using a catheter and a hydrophilic guide wire. After lesion crossing, a sheath is positioned within the obstruction, over a super-stiff guide wire, positioned within the duodenum. The super-stiff guide wire is left for safety; then the biopsy forceps device is inserted by the wire, through the sheath, and is pushed and advanced open within the lesion under fluoroscopic guidance, using the sheath for support, trying to obtain specimens at the centre of the stricture (Figs. 5 and 6). Usually four hands are necessary for this procedure. Three to five biopsy specimens are taken from the lesion; they are fixed with formalin and sent to the pathology department for analysis. Then an internal–external biliary draining catheter is positioned; if the obstruction cannot be outdated, an external drainage has to be placed. Finally, a cholangiogram is performed to evaluate the potential extravasation of contrast material from the biopsy site (Ierardi et al. 2014; Inchingolo et al. 2018; Andrade et al. 2017; Jung et al. 2002).

3.4 Complications

Complications are rare (4–6%) (Jung et al. 2002; Park et al. 2017; Li et al. 2014), and are usually haemobilia or biloma. No major complications are reported in literature (Ierardi et al. 2014; Inchingolo et al. 2018).

Theoretically, PTCB could cause vascular or bile duct rupture leading to bile leakage and haemobilia, but this is rare in practice because, even if portal bile duct structures lie adjacent to the lumen, fat and fibrous connective tissue fill the

spaces between them (Li et al. 2016). The complications reported are usually caused by the puncture of the liver or by the drainage process rather than by the biopsy procedure (Ierardi et al. 2014; Jung et al. 2002; Park et al. 2017; Perez-Johnsto et al. 2018) and can also be infection or tumour seeding along the course of the biliary catheter (Venkatanarasimha et al. 2017).

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