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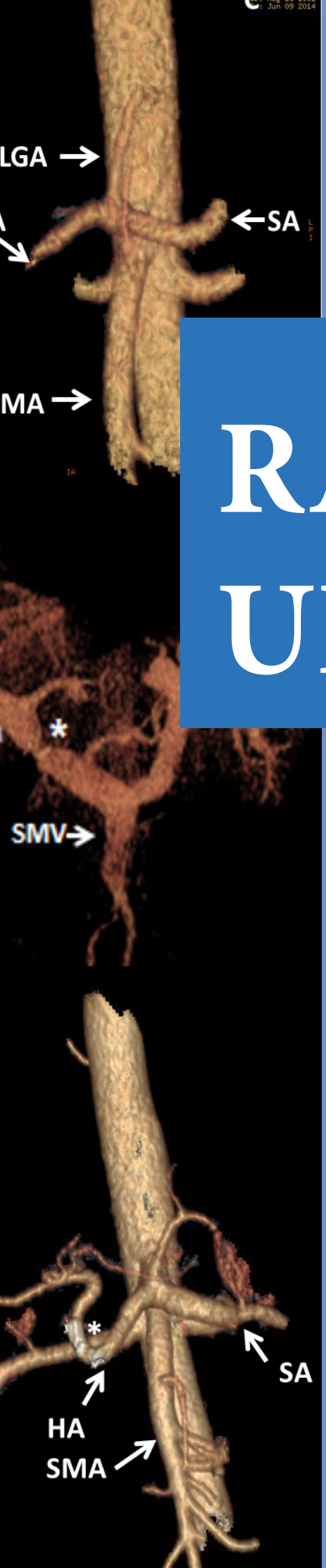

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CONTENTS

ULTRASOUND IMAGING OF VASCULAR COMPLICATIONS AFTER ADULT ORTHOTOPIC LIVER TRANSPLANTATION

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ABSTRACT
Liver transplantation is important treatment option for end-stage liver disease. With the gradual improvements in surgical technique and immunosuppression therapy, liver transplantation became the first line treatment for acute or chronic end stage liver disease, and in some cases malignancies or metabolic disorders. Vascular complications are the most common and dreaded complications on the early period after liver transplantation. Arterial thrombosis is the one that has most severe or even life threatening outcome. Early diagnosis of these complications can lead to early treatment and better graft and patient survival results and imaging plays a crucial role in the diagnosis of vascular complications. Ultrasound is the first choice imaging modality in early postoperative period, because of its availability, portability and good sensitivity in detecting vascular complications. This article describes the normal and transient vascular ultrasound findings after liver transplantation, reviews vascular complications after orthotropic liver transplantation and presents several clinical cases from our transplantation center.

Keywords: orthotopic liver transplantation, vascular complications, ultrasound

INTRODUCTION

Liver transplantation is important treatment option for end-stage liver disease. The most common indications for liver transplantation are listed in Table 1 and liver cirrhosis is most frequent of all (52%). According to European Liver Transplantation registry (ELTR) there is about 6000 liver transplantations per year in Europe and similar amount is in United States (1). First successful orthotopic liver transplantation (OLT) was performed by Thom Starzl from Colorado university in 1967 (2). Unfortunately till 1988 one year survival was only up to 33%. Gradual improvements in surgical technique, better selection of patients and improved postsurgical management of complications and immunosuppression therapy led to better one year survival rates up to 81% (1). However there is still considerable amount of postoperative complications after liver transplantation. There are few different classifications of postoperative complications one of them is made according to the origin of complications is listed in Table 2. Another way to classify post-operative complications is according to timing excluding two main groups of early (up to one month after OLT) and late (more than one month after OLT) complications (4). In the early post-operative period vascular complications are one of the main causes of patient morbidity and death (1). Nowadays the incidence of vascular complications is generally about 7.2-15% (4). In cases such as split liver transplantation, live donor liver transplantation or children liver transplantation rate can be as high as 20% (5,6). Arterial complications are the most common (5-10%) vascular complications after OLT. Early hepatic artery thrombosis more often may need retransplantation while venous complications including portal and caval venous problems are less frequent and can usually be treated by surgical or endovascular intervention (5).

As there are no specific clinical or laboratory features of arising vascular complications imaging has the pivotal role in posttransplantation period

Table 1 Indications for liver transplantation (3).

Acute liver failure	• Hepatitis A/B • Intoxication (e.g., acetaminophen, death cap) • Wilson's disease • Budd–Chiari syndrome
Chronic liver failure: Non-cholestatic cirrhosis	• Hepatitis B/C • Autoimmune hepatitis • Alcohol-induced cirrhosis
Chronic liver failure: Cholestatic cirrhosis	• Primary biliary cirrhosis (PBC) • Primary sclerosing cholangitis (PSC) • Secondary biliary cirrhosis
Chronic liver failure: Metabolic	• Wilson's disease • Hemochromatosis • α-1 Antitrypsin deficiency • Amyloidosis • Cystic fibrosis
Chronic liver failure: Vascular	• Tyrosinemia • Budd–Chiari syndrome
Other indications	• Primary oxalosis • Gycogen storage diseases • Hyperlipidemia • Polycystic liver disease
Malignant disease	• Hepatocellular carcinoma (within Milan criteria) • Fibrolamellar carcinoma • Hepatoblastoma • Epitheloid hemangioendothelioma • Cholangiocellular adenocarcinoma • Neuroendocrine liver metastases
Benign liver tumors	• Adenomatosis

to monitor the transplant allograft and screen for possible complications. Early detection of complications is essential to ensure appropriate treatment and preserve graft function (7). Ultrasound (US) is the first line imaging modality, because of its availability, portability, and cost effectiveness, also it has no radiation or nephrotoxic effect of contrast media.

On the other hand, there are some shortcomings of this modality as it is very much operator dependent and the evaluation may be difficult depending on patient constitution type or lack of suitable acoustic window. The use of a contrast enhanced US (CEUS) may help improve the sensitivity of the modality for detection of slow vascular flow or small intraluminal thrombus (9). CEUS can be performed at the bedside in the intensive care unit, avoiding most of the risks associated with contrast enhanced computed tomography (CT) or angiography (10). Another alternative, that may improve US imaging in difficult to image cases are new vascular imaging techniques such as B-flow (General Electric Healthcare) (Video 1-2), eFlow (Hitachi Medical Systems) or Superb Micro-Vascular Imaging (SMI, Toshiba Medical Systems) (Video 4-5), that do not require contrast media, but allows to depict low-velocity microvascular blood flow and has a high temporal and spatial resolution

Video 1. Patient after liver transplantation. Ultrasound B-flow scale. Common hepatic artery and portal vein visualised. ***(Click to play video)***

Table 2 Classification of postoperative complication after liver transplantation according origin (8).

Vascular complications	Biliary complications	Other complications
Hepatic artery:	• Obstruction	Infection, abscess
• Thrombosis	• Stones	Hematoma
• Stenosis	• Stricture	Neoplasm
• Pseudoaneurysm		Cirrhosis and its complications
Portal vein:	**Bile leak and biloma**	Rejection
• Thrombosis		Bowel perforation
• Stenosis		
• Pseudoaneurysm		
Inferior caval vein or hepatic veins:		
• Thrombosis		
• Stenosis		

(11). Multidetector contrast enhanced computer tomography or magnetic resonance imaging (MR) may be employed as second step imaging modalities in unclear situations. Digital subtraction angiography (DSA) is usually chosen when endovascular treatment is planned along with the diagnostic imaging. Diagnostic imaging algorithm is listed in Table 3.

Table 3 Imaging evaluation of vascular and biliary complications after orthotopic liver transplantation (8) .

Type of complication	Initial study	Subsequent study	Final invasive study
Vascular	Vascular ultrasound	CEUS CT angiography, MR angiography	Digital subtraction angiography
Biliary	Greyscale ultrasound	MR cholangiopancreatography, CT, Hepatobiliary scintigraphy	ERCP, percutaneous transhepatic cholangiography

CEUS – contrast enhanced ultrasound; CT – computed tomography; MR – magnetic resonance; ERCP – endoscopic retrograde cholangioprancreatography.

SURGICAL TECHNIQUE

Orthotopic liver transplantation requires total hepatectomy and substitution of the native liver by donor liver in the right hypochondrium. Usually it includes three vascular anastomoses: hepatic artery (HA), portal vein (PV) and inferior vena cava (IVC). HA anastomosis is usually "fish-mouth" type end-to-end anastomosis and its location depends on the length and calibre of the vessel but is typically performed near the branch point of gastroduodenal and proper hepatic arteries of the recipient (12,13). In case of atypical arterial anatomy additional and more complicated arterial reconstructions may be necessary. In the event of recipient hepatic artery or celiac axis high-grade stenosis an aortohepatic interposition jump graft using donor iliac artery may be used (14). The donor and recipient portal veins are usually anastomosed end-to-end. Although tapered anastomosis may be required when a significant size mismatch exists between the recipient and the donor veins (15). PV thrombosis used to be an absolute contraindication to liver transplantation but is no longer a contraindication, because a segment of donor-derived iliac vein may be used as an interposition jump graft anastomosed to the recipient superior mesenteric vein (7).

There are several surgical techniques for IVC anastomosis. The main difference between them is that recipient hepatectomy may or may not include the retrohepatic IVC segment. In the older standard approach, the recipient's retrohepatic IVC is removed with the diseased liver, and end-to-end anastomosis of the recipient and donor IVCs is performed twice (12). The other technique that is presently used in most institutions is IVC preserving or "piggyback" technique. Several methods of graft-to-inferior vena cava implantation during orthotopic liver transplantation with preservation of the caval flow have been described (16). In our center we use the "piggy-back" modified by Belghiti technique, when a side-to-side anastomosis is created between two newly made openings: one on the anterior wall of the recipient IVC and other on the posterior wall of donor IVC. Both sides of donor IVC are closed. The main advantage of the caval preservation achieved with the "piggyback" technique is hemodynamic stability, a result of continued blood flow from the lower extremities and renal veins throughout the surgery (17). The main disadvantage is that there is still a risk of complications and most often of them are Budd-Chiari syndrome and liver parenchyma bleeding caused by parenchyma injury while creating anastomosis.

POSTOPERATIVE ULTRASOUND

US is the first line imaging modality in evaluation, detection, and follow-up of vascular complications after OLT. Doppler US screening protocols for vascular complications are highly variable among different transplantation centers with respect to frequency and interval of screening, and the time period after operation during which screening was performed (18). Usually first US examination is performed in first 24h after OLT and further follow-up may be done every day for the first week or may be repeated only 5-7 days after OLT, or even it may be chosen to repeat the examination only when it is clinically indicated (19–21).

Some transplantation centers also use intraoperative Doppler US, just after vascular anastomoses are created. Main advantage of intraoperative Doppler US is that we can evaluate vascular anastomoses and make an early diagnosis of possible complications, when appropriate action can be done on the same time, avoiding additional laparotomies and also possible consequences to the graft function and bile ducts ischemia (22, 23).

Nevertheless, which protocol is chosen, standard US evaluation of the postoperative liver transplant should consist of grayscale examination of the liver parenchyma, bile ducts and surrounding structures and grayscale, colour and pulsed Doppler evaluation of HA, PV, hepatic veins and IVC at the site of anastomosis and intrahepatic branches (14). Awareness of the normal US appearance of the transplanted liver and possible transient findings permits detection of complications and prevents misdiagnoses.

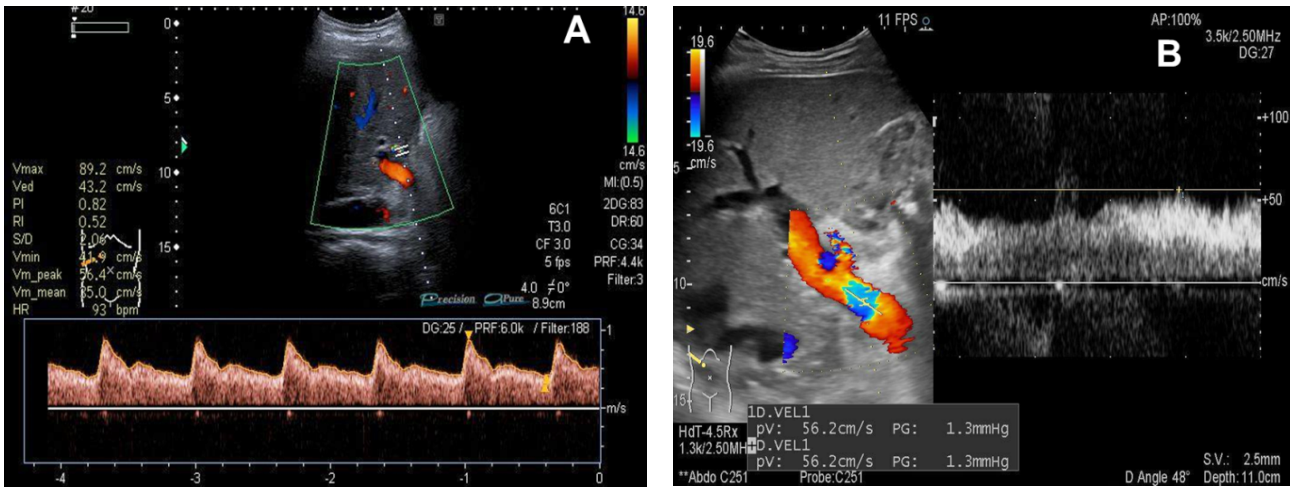
The normal HA should show a pulsatile antegrade, low resistance waveform with continuous diastolic blood flow (Figure 1 A) (24). The

acceleration time (AT), which represents the time from end diastole to the first systolic peak, should be less than 0.08 s, and the resistive index (RI), which represents the ratio of (peak systolic velocity- end diastolic velocity)/peak systolic velocity, should be between 0.5 and 0.8 (24,25). It is important to evaluate the right and left HA branches, because a normal hepatic artery waveform obtained at the porta hepatis does not exclude a hepatic artery obstruction. Whenever possible, the anastomosis also should be examined (9). The most common transient hepatic arterial waveform abnormality seen in the immediate postoperative period is increased hepatic arterial RI, due to decreased diastolic flow (19). This transient elevation of RI is likely secondary to allograft oedema, increased cold ischemia time, increased portal flow or vessel spasm (26). The other causes of abnormal RI are listed in Table 4. Although the mean normal hepatic arterial peak systolic velocity (PSV/Vs) is 103 cm/s, in the early period even in healthy liver it may vary from 13.2 up to 367 cm/s (12,21). Elevated hepatic arterial velocity in the immediate postoperative period may be caused by transient persistence of the preoperative high-arterial-inflow state, which is caused by portal hypertension (21). Also higher velocity at the anastomosis site

Table 4. Causes of elevated and decreased hepatic artery resistance (12,24,27).

Causes of elevated hepatic artery resistance	Causes of decreased hepatic artery resistance
Pathologic (microvascular or disease) • Chronic hepatocellular disease (including cirrhosis) • Hepatic venous congestion • Transplant rejection • Any other disease that causes diffuse compression or narrowing of peripheral arterioles	**Proximal arterial narrowing** • Transplant stenosis • Atherosclerotic disease (celiac, hepatic) • Arcuate ligament syndrome
Physiologic • Postprandial state • Advanced patient age	**Distal (peripheral) vascular shunts (arteriovenous, arterioportal fistula)** • Cirrhosis with portal hypertension • Posttraumatic or iatrogenic causes • Hereditary haemorrhagic telangiectasia (Osler-Weber-Rendau syndrome)
Transient (early postoperative period) • Oedema • Increased cold ischemia time • Increased portal flow • Vessel spasm • Older age of liver donor	**Transient (early postoperative period)** • Liver oedema • Oedema at the anastomosis site • Systemic hypotension

Figure 1. Normal hepatic artery and portal vein flow on Doppler ultrasound after orthotopic liver transplantation A. US triplex scan image. Normal arterial blood flow in hepatic artery: pulsatile antegrade low resistance waveform Vs. 89 cm/s, RI 0,52. B. US triplex scan image. Normal blood flow in portal vein: hepatopetal spectral waveform Vmax. 56,2 cm/s.



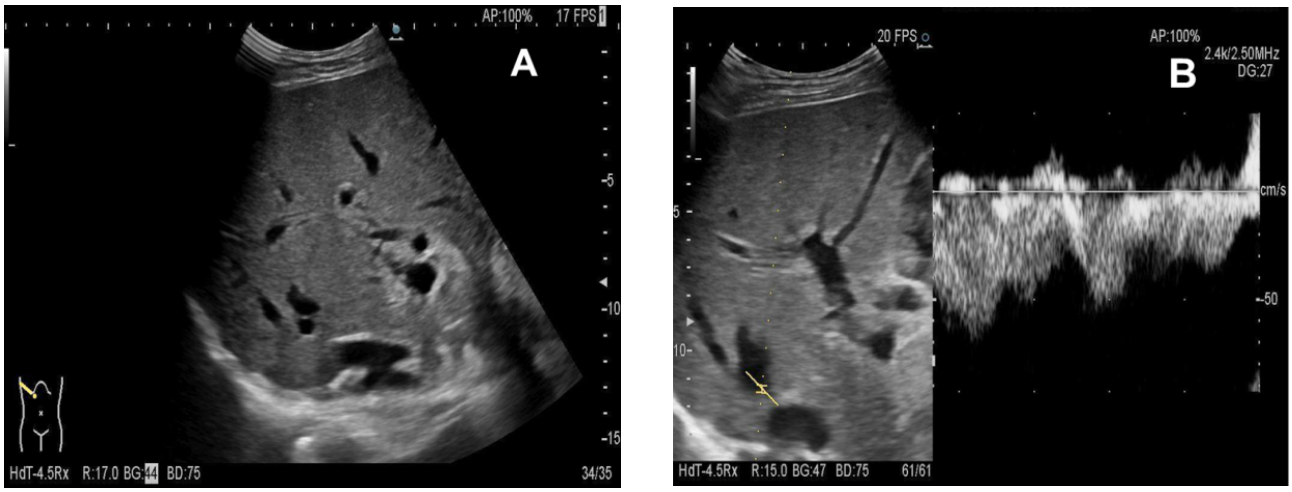
might be caused by surrounding tissue oedema. Also in case of arterial kinking the angle of insonation should be set correctly (up to 60 degrees) to make and appropriate differentiation from true arterial stenosis. Doppler US arterial waveform abnormalities on the immediate postoperative scans should be followed and correlated with the patient's clinical findings including liver function laboratory tests. Transient HA waveform changes usually resolve in 7-15 days (19).

The normal PV Doppler waveform is a continuous flow pattern toward the liver with mild velocity variations induced by respiration (Figure 1 B) (27). The blood flow mean velocity at the anastomosis site is normally about 58 cm/s (12). However increases in PV velocities can be seen in immediate postoperative period likely because of compressibility caused by postoperative inflammation or fluid collections (20). The velocity should decrease gradually on a first week after transplantation, but M. Bolognesi et al in his study declares that portal blood flow may decline gradually for up to 2 years after liver transplantation (21,28).

Normal Doppler wave appearance of the hepatic veins and IVC shows a phasic flow pattern (conventionally triphasic), reflecting the physiologic changes in the blood flow during the cardiac cycle (Figure 2) (27).

But on early postoperative period monophasic or biphasic waveforms are commonly seen secondary to graft oedema or compression by the adjacent fluid collection. This usually normalises on follow-up studies in a few days (19).

Figure 2. A. Ultrasound greyscale image. Vena cava inferior „pigg-back" modyfied by Belghiti anastomosis axial view. B. Ultrasound duplex scan image. Right hepatic vein triphasic spectral vaweform.



Video 2. Patient after liver transplantation. Ultrasound B-flow scale. Active flow in hepatic veins and vena cava inferior anastomosis.

ARTERIAL COMPLICATIONS

THROMBOSIS

HA thrombosis is the most frequent of all arterial complications following OLT and is found in 2-12 % of cases (29) . J. Bekker et al. in his systematic review reported the median time to detection of HA thrombosis was 6.9 days (range 1–17.5 days postoperative) (18). Although the real causes of HA thrombosis are is still a source of debate usually early HA thrombosis is mainly associated with technical (surgical) problems such as difficult anastomosis, kinking, stenotic anastomosis, small vessel size, reduction in a disparate diameters of the arteries, the presence of multiple arteries, aberrant or complex donor/recipient arterial anatomy or arterial abnormalities requiring complex arterial reconstructions, use of aortic conduit and etc. (18,30,31). Those problems are more common among centers performing fewer than 30 OLT a year; the incidence of HA thrombosis diminishes with the surgical team's experience. Therefore, surgical causes probably do not represent the main risk factor for HA thrombosis (4). Regarding nonsurgical risk factors involved in the appearance of HA thrombosis, we can identify donor age >60 years, extended cold ischemia time, lack of ABO compatibility, cigarette smoking, hypercoagulability, preservation damage to the endothelium, a donor positive for cytomegalovirus (CMV) and CMV-negative in a recipient (31).

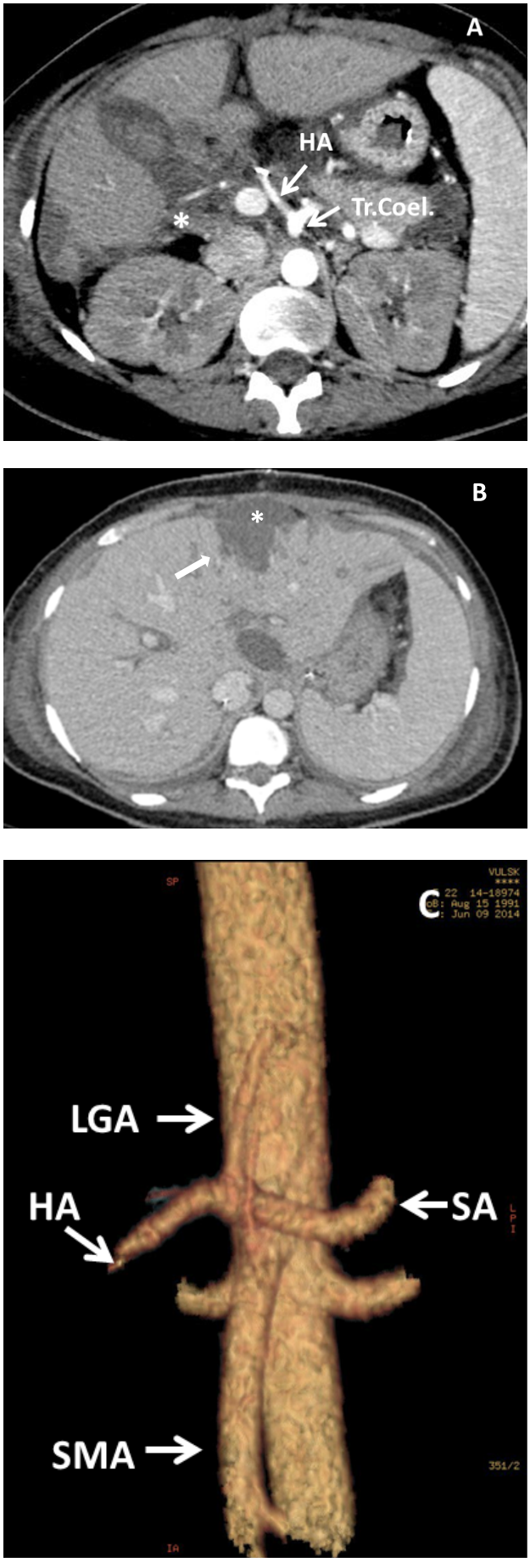


Figure 3. Female patient E.P., 22 years old, days 11 days afer orthotopic liver transplantation. A-C. CTA arterial phase images, axial plane (A) and 3D (C) reconstructions, no contrast media in donor hepatic artery or intrahepatic arterial branches - hepatic artery thrombosis. B. CTA portovenous phase images, ischemic zone (arrow) in 4A liver segment and perihepatic fluid colection (asterisk). CTA- computed tomography angiography. HA – hepatic artery, Tr. Coel. – truncus coeliacus, LGA – left gastric artery, SA – splenic artery, SMA – superior mesenteric artery.

Without prompt treatment HA thrombosis carries an incidence of graft failure and mortality of more than 50% (4). The bile ducts in a liver transplant are supplied exclusively by small branches of the hepatic arteries, so hepatic artery thrombosis can lead to biliary ischemia, strictures and necrosis (Video 3, Figure 6) (13). Up to 50% of patients with late HA thrombosis can be asymptomatic with only elevated liver transaminases (9). Symptomatic patients often present with biliary complications with recurrent cholangitis, abscess and biliary leakage or stricture, and the presentation may be insidious (Figure 3-6) (5). Indeed, clinical expression depends on the existence of collaterals, which can develop as early as within two weeks. Prompt diagnosis of hepatic artery thrombosis is extremely important because early intervention (with thrombectomy, hepatic artery reconstruction, or both) may allow graft salvage (25). The rate of retransplantation in untreated HA thrombosis is 25-83% while it is 28-35% in patients who underwent revascularization (5).

A US-based diagnosis of hepatic artery thrombosis is established in the absence of flow in the hepatic and intrahepatic arteries at colour and pulsed Doppler imaging. The Doppler US imaging findings allow correct diagnosis in an estimated 92% of cases (25). The sensitivities of duplex Doppler imaging compared with angiography are 100% for the detection of early hepatic artery thrombosis and 72.7% for late hepatic artery thrombosis (32). Nevertheless, CTA and DSA should be considered as second step imaging choice (Figure 3-4).

Temporal progression of Doppler sonography findings from initially normal diastolic flow to absent diastolic flow, dampening of the systolic peak, and finally complete loss of hepatic arterial flow has been described as the "syndrome of impending thrombosis" and is a strong predictor of hepatic artery thrombosis (33).

Figure 4. Female patient, 22 years old, 11 days after orthotopic liver transplantation hepatic artery thrombosis occurred, percutaneous angioplasty treatment (thrombectomy, balloon dilatation and stent placement in hepatic artery) was done. A. DSA image after hepatic artery recanalization and angioplasty, recipient and donor hepatic artery segments and its branches are filled with contrast media. B. CTA arterial phase 3D reconstruction image. Hepatic artery patency is restored, anastomotic site stent (asterisk). CTA - computed tomography angiography; DSA – digital subtraction angiography; HA – hepatic artery; SMA – superior mesenteric artery; SA – splenic artery.

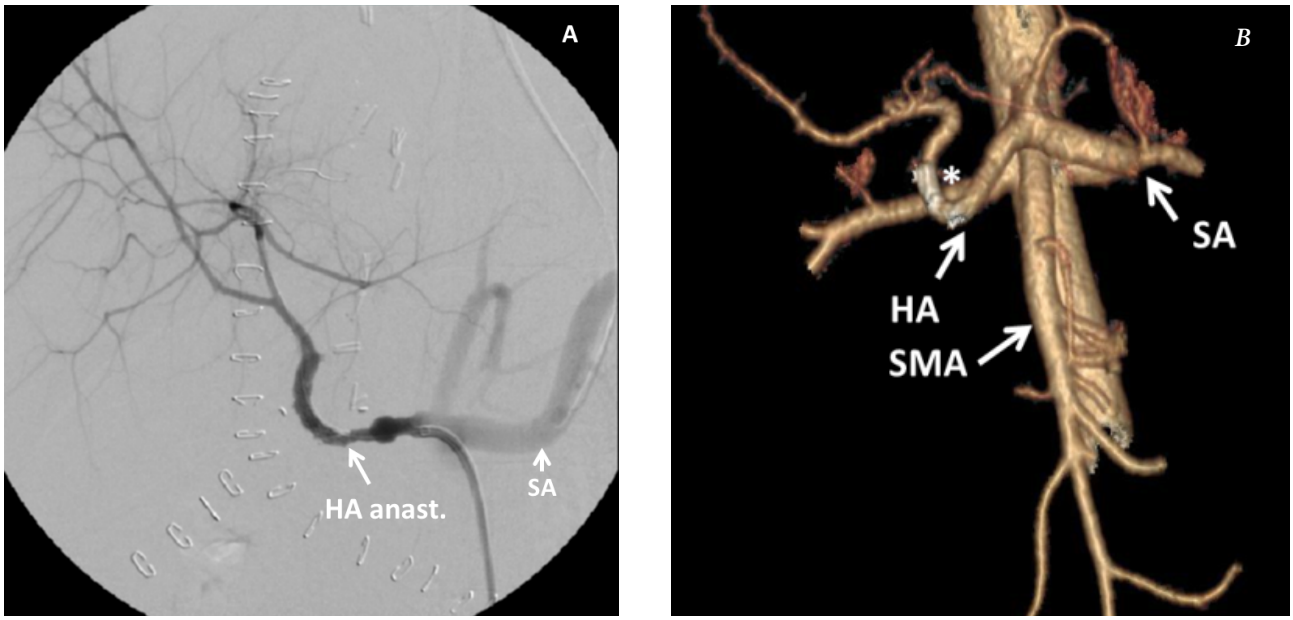


Figure 5. Female patient, 22 years old, on 11th day after orthotopic liver transplantation hepatic artery thrombosis occurred, percutaneous angioplasty and stenting was done, control Doppler ultrasound exam on the next day. A. Normal arterial flow waveform at the anastomosis Vs 127 cm/s, RI 0.54. B. Normal arterial flow in the right intrahepatic branch, Vs 52 cm/s, RI 0.51.

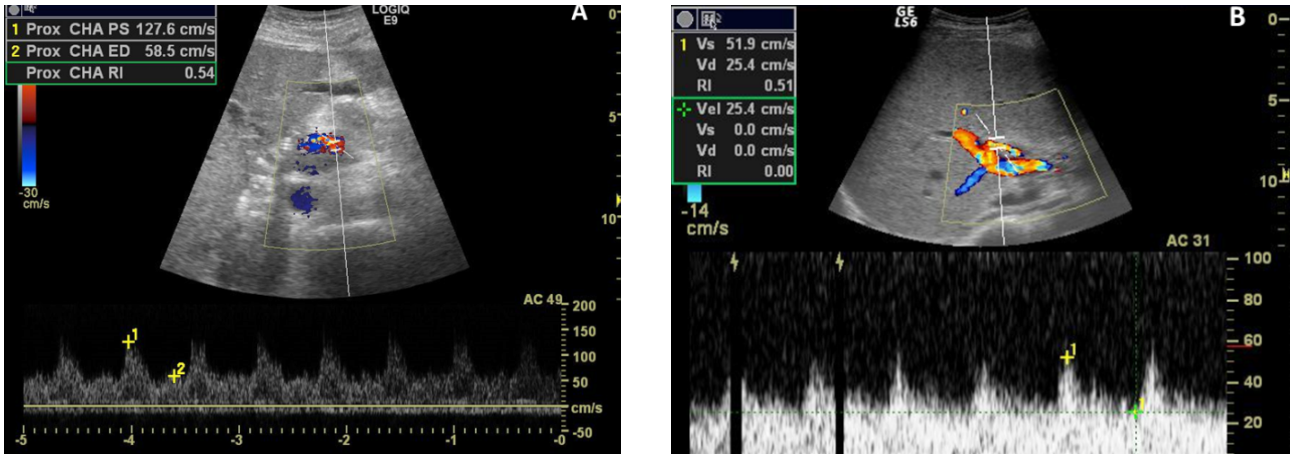


Figure 6. Female patient, 22 years old, on 11th day after orthotopic liver transplantation hepatic artery thrombosis occurred, percutaneous angioplasty and stenting was done. One and a half month after treatment intrahepatic cholestasis and extrahepatic bile duct stricture occurred. Endoscopic retrograde cholangiopancreatograpgy image.

Video 3. Ultrasound color Doppler scale. Female patient, 22 years old, on 11th day after orthotopic liver transplantation hepatic artery thrombosis occurred, percutaneous angioplasty and stenting was done. One and a half month after treatment intrahepatic cholestasis occurred.

Reduced flow, whether secondary to spasm or to low cardiac output, can also cause non-visualization of flow at Doppler US and be a cause of false positive diagnosis (8). In such cases microvascular ultrasound imaging techniques or even CEUS might be useful to clarify the diagnosis.
Also hepatic arterial collaterals may develop in chronic thrombosis and demonstrate low intrahepatic arterial RI, mimicking stenosis and giving a false-negative diagnosis. Therefore, the sensitivity of ultrasound for the detection of hepatic artery thrombosis decreases as the interval following transplant increases (25).
Currently, the literature on the curative management of early HAT suggests the following procedures: first endovascular radiological intervention (intra-arterial thrombolysis, percutaneous transluminal angioplasty and stent placement) (Figure 4-5), secondly open surgical revascularization, and finally liver retransplantation, which is associated with the best survival rate compared with revision or thrombolysis, but is a limited therapeutic option due to organ shortage (4).

STENOSIS

HA stenosis has been reported to occur in 5%–11% of liver transplant recipients (25). Many patients with HA stenosis are asymptomatic and most commonly present only with abnormal liver function tests. This complication usually occurs at the site of anastomosis within 3 months after transplantation. If left untreated, it may lead to hepatic artery thrombosis, hepatic ischemia, biliary stricture, sepsis, and graft loss. Early detection of hepatic artery stenosis is crucial to allow treatment either with surgical reconstruction or with balloon angioplasty, or stent placement and avoid the necessity of retransplantation (7).
Doppler US is reported to have a sensitivity of 100%, a specificity of 99.5% a PPV of 95% and NPV of 100%, and overall accuracy of 99.5% in early diagnosis of HAS (34).
Doppler US findings include increased peak systolic velocity (>200 cm/s) at the stenosis site, and a low RI (< 0.5), a long AT (> 0.08 seconds), and a "tardus-parvus" waveform distal to the stenosis (Figure 7) (8).
Severe aortoiliac atherosclerosis and hepatic artery thrombosis with the formation of intrahepatic collateral vessels are two important pitfalls giving false-positive results, because flow through collateral vessels also may demonstrate a dampened arterial waveform (9).
In cases of false-negative results with Doppler US, the CEUS examination may be helpful. The microbubbles may boost the amplitude of the Doppler signals from the blood and improve the signal-to-noise ratio when the Doppler signals from the hepatic vasculature are severely attenuated (e.g. in severe HA stenosis), the so-

Figure 7. Female patient, 22 years old, 2 years after othotopic liver transplantation, and hepatic artery stenting, stenosis occured at arterial anastomosis. A. Ultrasound triplex image at hepatic artery stent site, low resistance pulsatile arterial vaweform is seen with a very high systolic velocity up to 392 cm/s. B. Ultrasound triplex image of right liver arterial branch, „tardus-parvus" type vaweform" is registered with a low resististance index (RI 0,36), and prolonged acceleration time.

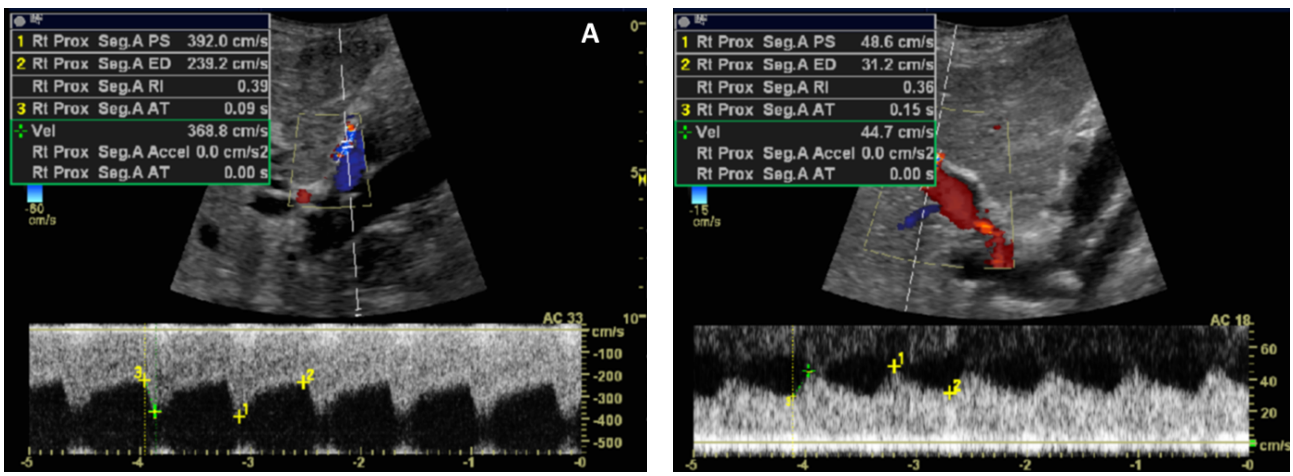
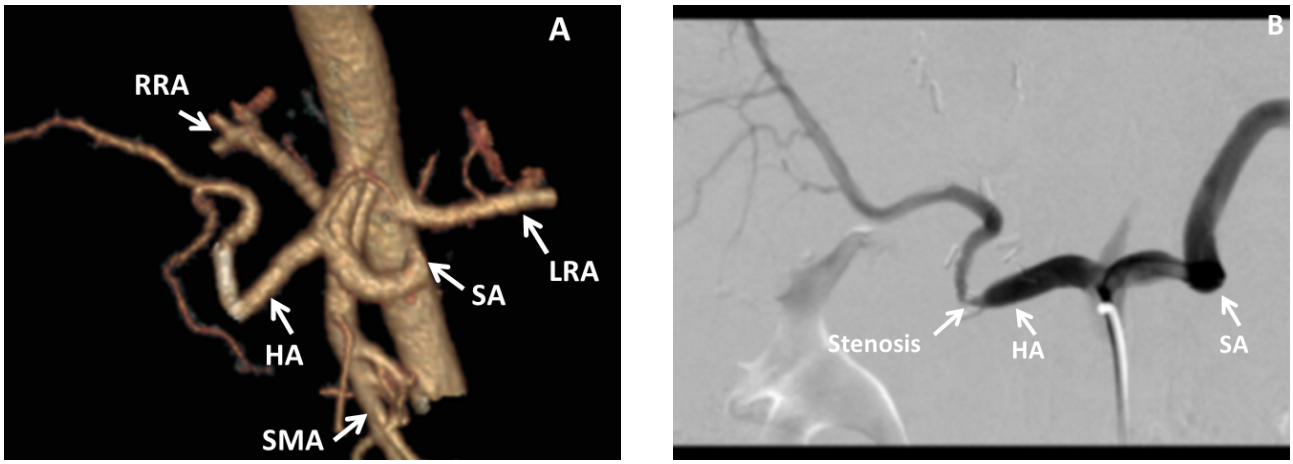


Figure 8. Female patient, 22 years old, 2 years after othotopic liver transplantation, and hepatic artery stenting. On control Doppler ultrasound exam suspicion of arterial stenosis, so CTA and DSA was done. A. CTA arterial phase 3D reconstruction, hepatic artery stenosis (75 %) at the proximal part of endoluminal stent, baucause of stent angulation. B. Digital subtraction angiography shows hepatic artery stenosis baloon dilatation was successfully performed. CTA – computed tomography angiography; DSA – digital subtraction angiography; RRA – right renal artery; LRA – left renal artery. HA – hepatic artery; SMA – superior mesenteric artery; SA – splenic artery;



called Doppler rescue (35). When CEUS is not available new non-contrast microvascular ultrasound imaging techniques such as SMI, B-Flow or e-Flow can be useful.

Radiological endovascular intervention by percutaneous transluminal angioplasty with or without stent placement is often used to treat posttransplant HAS (Figure 8) and are both efficacious, with 7% to 12% of complications including dissection and arterial rupture, restenosis or thrombosis (25%) and failed attempts (12%). Surgical revision and retransplantion showed a high rate of success, but the overall mortality rate was as high as 20% (4).

PSEUDOANEURYSM

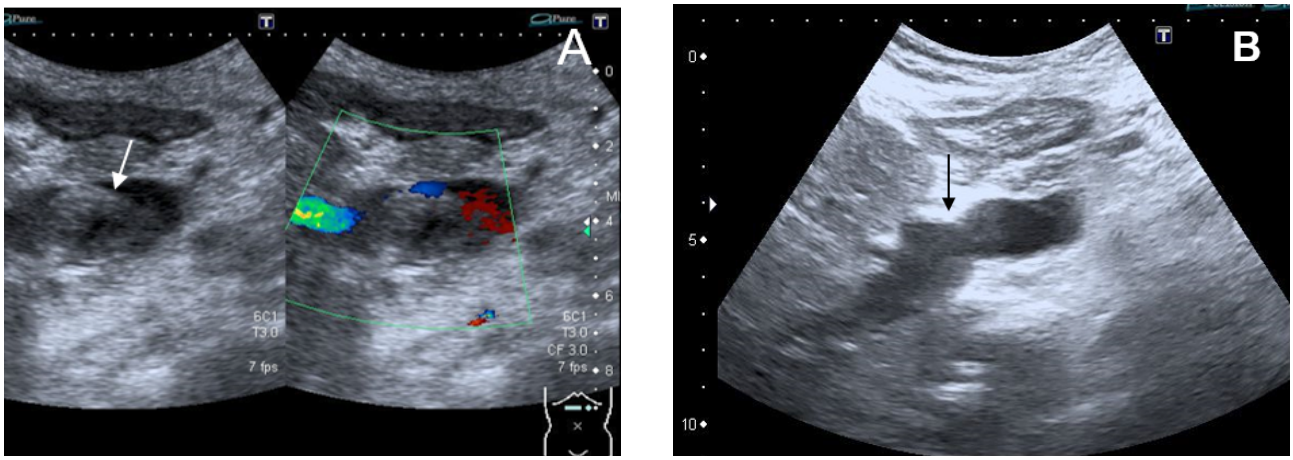
Arterial pseudoaneurysms are rather rare complications after OLT and occur only in up to 3% of cases(4). Nevertheless this condition may be life threatening and is associated with more than 50% mortality (5). Pseudoaneurysms may be intrahepatic and extrahepatic, the latter are more frequent and usually form at the location of arterial anastomosis or at the site of ligation of donor gastroduodenal artery (36). An intrahepatic pseudoaneurysm occurs as a consequence of a liver biopsy or after a focal parenchymal infection (27). Timely diagnosis is important because of impending rupture and life-threatening haemorrhage. On Doppler US images, a hepatic artery pseudoaneurysm appears as a cystic structure, usually near the course of the hepatic artery; its lumen is colour-filled, demonstrating a turbulent arterial flow, or "yin and yang" sign (9). It is important to note that US depiction of a fluid collection near the arterial anastomosis on the greyscale requires further evaluation with Doppler US to rule out pseudoaneurysm (8). Usually pseudoaneurysms may be treated by either endovascular or surgical procedures and both may be equally effective. However patients who undergo angioembolisation have more rapid bleeding control and shorter hospital stay after the treatment (37).

PORTAL VEIN COMPLICATIONS

THROMBOSIS

Acute PV thrombosis is rare after liver transplantation, with a reported incidence between 1 % and 2 % (35). Early PV thrombosis is more frequent than the late PV thrombosis with a median time to diagnosis of 5 days following OLT (range: 1 to 15 days) (4).

Figure 9. Male patient, 31 years old, 4.5 years after liver transplantation. Acute thrombosis in portal vein occurred at the site of anastomosis. A. Doppler ultrasound image heterogeneous mass is filling the lumen of the portal vein at the pre-anastomotic site – subacute portal vein thrombosis. B. The same patient ultrasound greyscale image after 6 months there is no thrombus seen in the lumen of portal vein – recanalization.



Factors associated with PV thrombosis include technical problems, small diameter of the portal vein (< 5 mm), donor-recipient PV diameter mismatch, previous splenectomy, simultaneous thrombectomy for pre-existing PV thrombosis and use of venous conduits for portal vein reconstruction. Additionally, longer cold ischemia time (> 12 h) can be a risk factor for developing venous complications. This can be due to difficulties in venoplasty (and more manipulation) before anastomosis (5).

The clinical presentation depends on the time the thrombosis occurs (4). Acute PV thrombosis during the early course after liver transplantation may result in graft failure requiring retransplantation. Portal hypertension with accompanying ascites and oesophageal varices may develop as a consequence of late portal vein stenosis or occlusion. (38).

Doppler US should be the first imaging tool used and is easily employed to evaluate vascular patency. It allows, in most cases, for an immediate non-invasive diagnosis and provides a rapid evaluation of vascular flow patency (4). US greyscale imaging of occlusive portal vein thrombosis shows an echogenic luminal thrombus with no Doppler flow, in case of partial non-occlusive thrombosis fluttering thrombus may be seen (Figure 9) (27). Thrombus appearance on ultrasound depends on its age. Usually an acute thrombus is anechoic on greyscale imaging, and only colour Doppler imaging may reveal the filling defect. This emphasizes the necessity for careful assessment of the portal vein throughout its entire length with both greyscale and colour Doppler. CEUS may aid in assessment of the severity of portal insufficiency, by demonstrating parenchymal perfusion status. It also facilitates the demonstration of a small thrombus in a peripheral portal branch (35). In unclear cases CT should be the second step choice (Figure 10-11). PV thrombosis treatment includes systemic anticoagulation therapy, catheter-based thrombolytic therapy by percutaneous radiological intervention (transhepatic or transjugular access depending of the coagulation state) with or without stent placement to portosystemic shunting (TIPS) to retransplantation in highly unresolvable cases (4).

STENOSIS

The true incidence of PV stenosis after OLT is not really known, and the only data reported in the literature concerning the incidence of venous complications is < 3% (4).

In practice, the majority of patients with PV stenosis are asymptomatic and the diagnosis of stenosis is an incidental finding detected on rou-

Figure 10. Female patient, 40 years old, first day after orthotopic liver transplantation. Computed tomography image portovenous phase multiplanar reconstruction, acute occlusive portal vein thrombosis occurred. PV – portal vein; SMV – superior mesenteric vein; SV – splenic vein; PSS – portosystemic shunts.

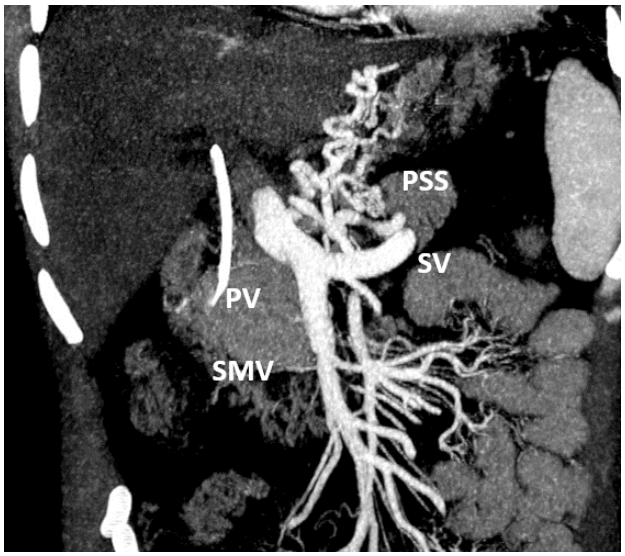
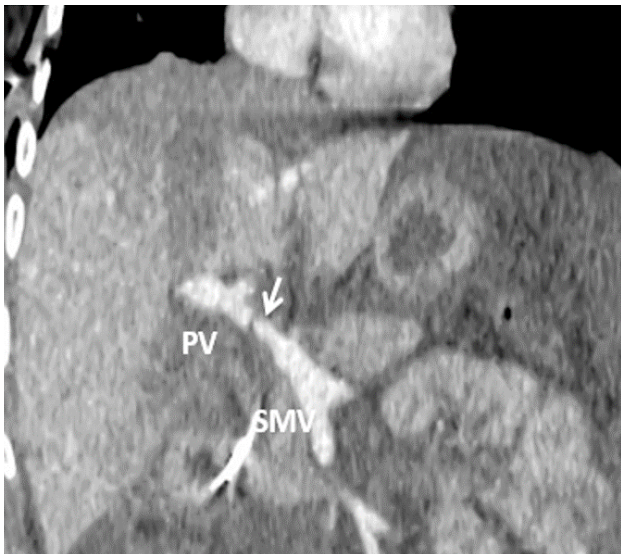


Figure 11. Male patient, 18 years old, 5th day after liver transplantation, computed tomography portovenous phase multiplanar reconstruction, non-occlusive intraluminal filling defect (arrow) in portal vein – non-occlusive portal vein thrombosis. PV - portal vein.



tine screening ultrasound (4). Only patients with high-degree stenosis (> 80%) develop symptoms. Therefore, even those patients with stenosis of the portal vein who developed symptoms such as portal hypertension with ascites and oesophageal varices could be treated conservatively (38). Nevertheless treatment is necessary as condition can evolve to thrombosis if not treated promptly. US findings of PV stenosis include narrowing of the main portal vein diameter of greater than 50% in adults or to less than a diameter of 2.5 lummen in children at the greyscale imaging, usually at the of the anastomosis (15).

Huang et al. described two Doppler US parameters for assessing PV stenosis after liver transplantation: a PV stenotic ratio greater than 50 % (pre-stenotic calibre – anastomotic site calibre/ pre-stenotic calibre) and a velocity ratio greater than 3:1 between the anastomotic and pre-anastomotic sites. Authors also found that cases of anastomotic site < 5 mm require interventional management for good long-term graft survival (39).

Chong et al. in his study reported that peak anastomotic velocity threshold of > 125 cm/s was 73% sensitive and 95% specific for stenosis (Figure 12-13). Also that a previously mentioned 3:1 velocity ratio was 73% sensitive and 100% specific for stenosis (32).

PORTAL VEIN ANEURYSMS

PV aneurysms are classified as intrahepatic and extrahepatic. Extrahepatic PV aneurysms have been defined as fusiform or saccular dilatation of main PV with luminal diameter greater than 20 mm. Intrahepatic aneurysms have been defined as lumen diameter greater than 9 mm and significantly larger than adjacent PV segments (40). Saccular structure is seen on the on the greyscale US imaging, and on Doppler US exam turbulent flow within aneurysm should be found (Figure 14).

Clinically smaller aneurysms are usually asymptomatic, whereas larger aneurysms are more often symptomatic and associated with

Figure 12. Female patient, 45 years old, one week after liver transplantation. Portal vein stenosis occurred. A. Ultrasound greyscale image, portal anastomosis site, significant narrowing of the lumen. B. Ultrasound triplex scan, high velocity blood flow at the site of portal vein anastomosis (237 cm/s).

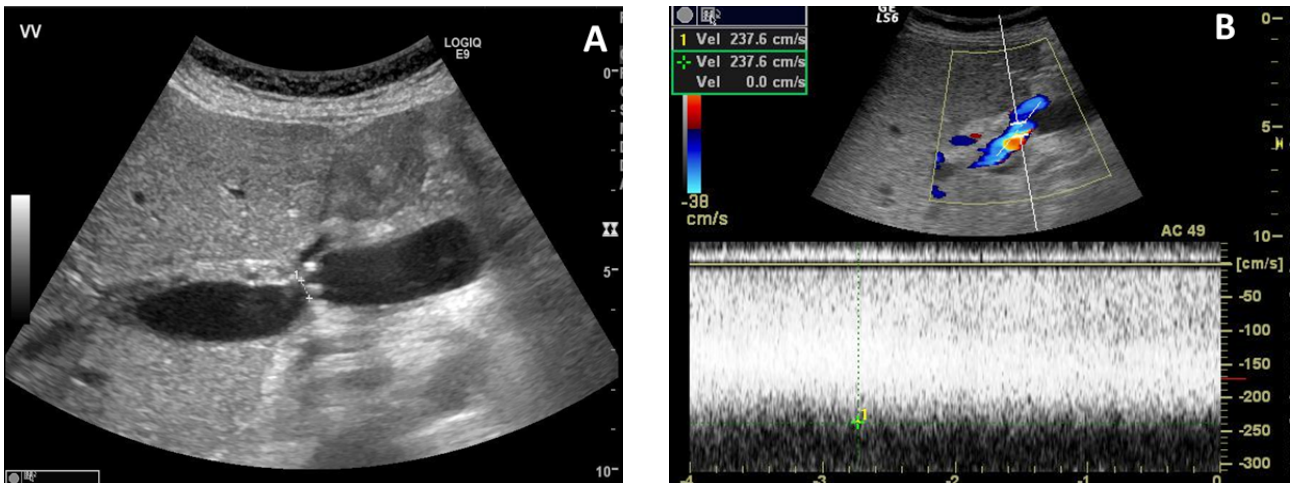
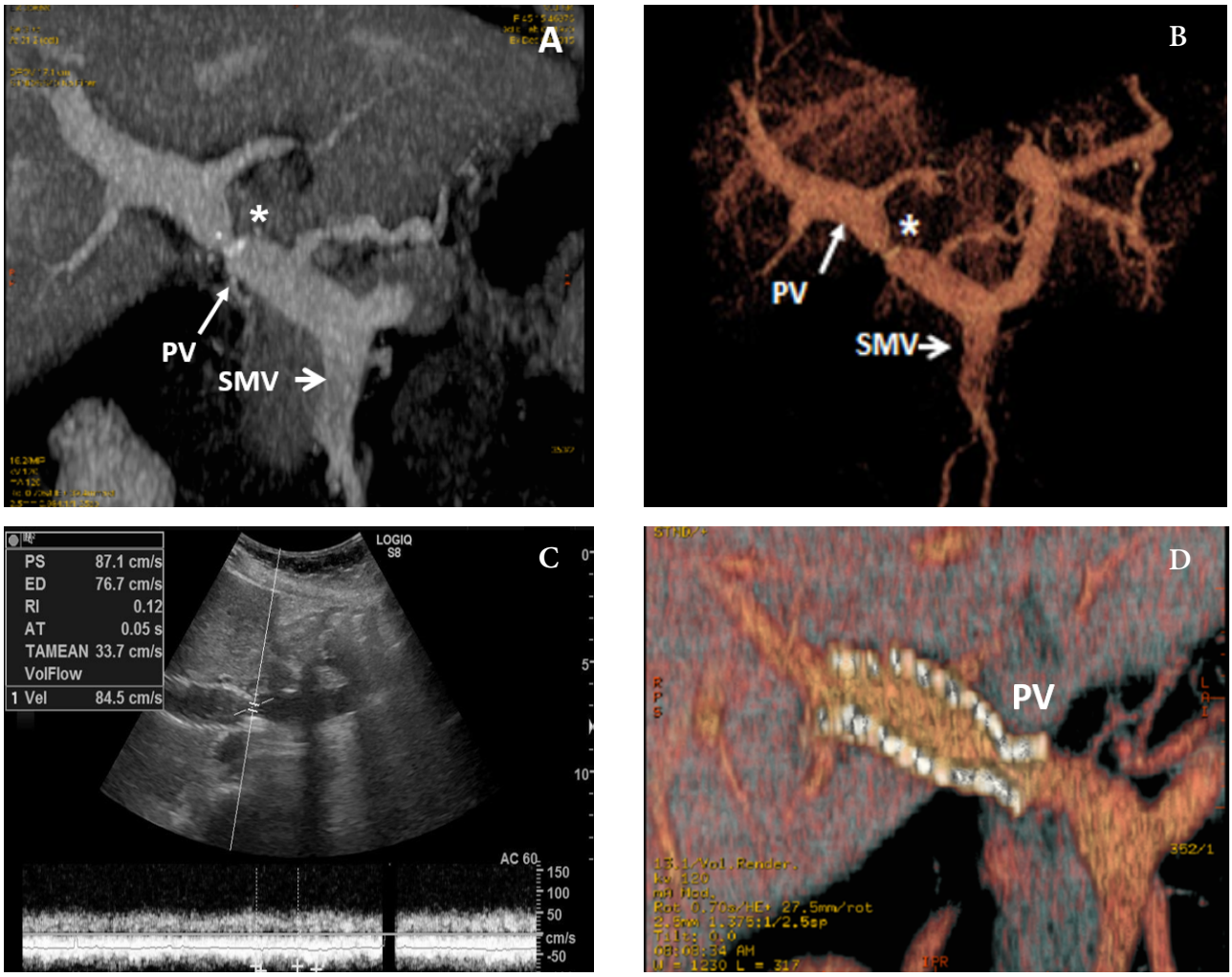


Figure 13. Female patient, 45 years old, one week after liver transplantation. Portal vein stenosis occurred (asterisk) diagnosed. A. CT portovenous phase, maximum intensity projection (MIP), portal vein stenosis up to 70 %. B. CT portovenous phase 3D rekonstruction. PV –portal vein, SMV – superior mesenteric vein. C. Ultrasound duplex scan image. The same patient after stenting procedure, normal blood flow velocity at the anastomosis site. D. CTA portovenous phase, 3D reconstruction, stent in portal vein. CT – computed tomography; PV – portal vein; SMV – superior mesenteric vein.



complications including thrombosis, portal hypertension, biliary tract obstruction caused by mass effect or rupture (14).

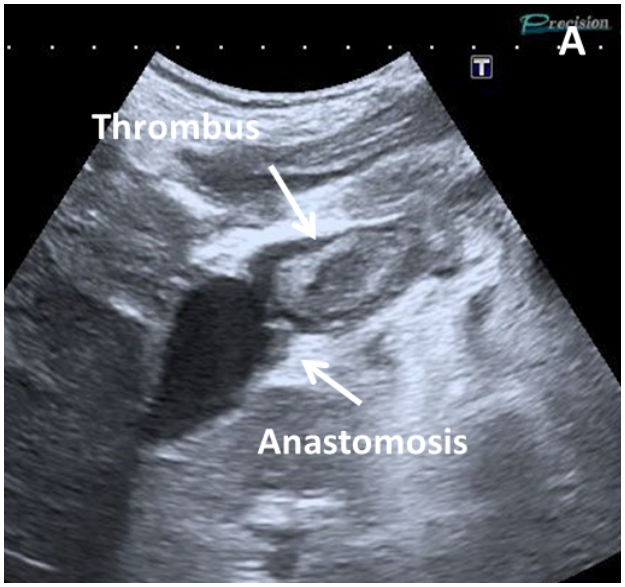
HEPATIC VEINS AND VCI COMPLICATIONS

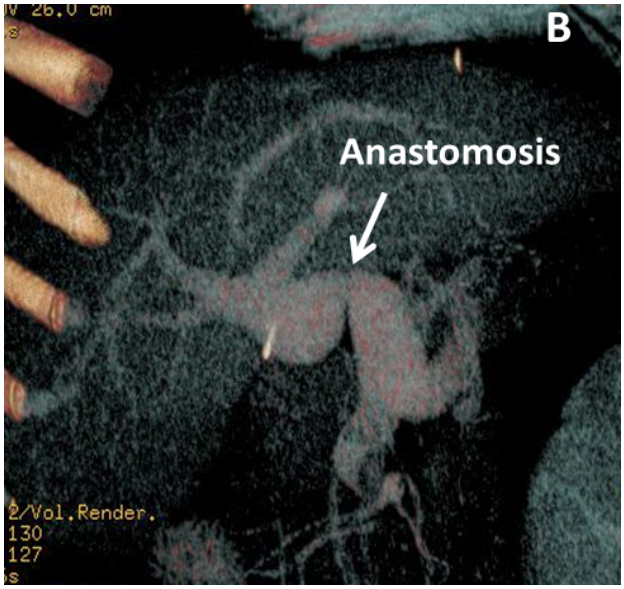
IVC complications occur in less 1% of liver transplant recipients (41). IVC stenosis and thrombosis are generally early complications occurring at the surgical anastomoses because of technical issues with the surgery (e.g. IVC kinking) and extrinsic compression from graft oedema, hematoma. Late IVC stenosis may be secondary to fibrosis and intimal hyperplasia (7).

The "piggyback" anastomosis has gained wide acceptance internationally and is the preferred technique for orthotopic liver transplantation at many institutions. However, it is especially vulnerable to two types of complications: (a) haemorrhage due to hepatic injury during surgery or due to cava-caval dehiscence (3% of cases) and (b) Budd-Chiari syndrome (0.3%–1.5% of cases) due to inadequate venous drainage (9).

Main risk factors related to IVC complications

Figure 14. Male patient, 31 years old, 4.5 years after liver transplantation. Aneurysmatic pre- and postanastomotic portal vein dilatation. A. Ultrasound greyscale image, portal vein lumen narrowing at the site of anastomosis, and aneurysmatic portal vein diltation in the preanastomotic and postanastomotic parts, chronic portal vein trombosis. B. Computed tomography portovenous phase, 3D rekonstruction. Portal vein anastomosis stenosis and aneurysmatic dilatation in preanastomotic and post-anastomotic sites.





are size discrepancy between the donor and recipient vessels, suprahepatic IVC kinking from organ rotation, fibrosis, chronic thrombus, neointimal hyperplasia, hypercoagulability, compression from graft oedema and adjacent fluid collections as well as transplants in paediatric patients(6).

Patients with hepatic venous outflow obstruction usually present with massive ascites and bilateral lower limb oedema between 2 and 16 months posttransplantation, which is refractory to oral protein supplements and maximal diuretic therapy. Some of the patients can develop acute Budd-Chiari syndrome early within the first week of posttransplantation (42).

In cases of IVC stenosis Doppler US demonstrates a three- to fourfold increase in velocity compared with the unaffected IVC, and associated colour Doppler aliasing. Indirect findings include distention of the hepatic veins with dampening and loss of phasicity of the hepatic venous Doppler waveform (8). IVC thrombosis is caused by surgical factors and a hypercoagulable state (22). In venous thrombosis, the vein may appear to be expanded, with a new thrombus appearing anechoic and an old thrombus

Video 4. Male patient, 49 years old, first week after liver transplantation. Middle hepatic vein thrombosis Ultrasound grey scale video.

Video 5. Male patient, 49 years old, first week after liver transplantation. Middle hepatic vein thrombosis is seen on Ultrasound SMI scan.

appearing echogenic at US. Duplex US shows an absence of signal in the presence of complete thrombosis. Partial venous thrombosis may appear as a nonocclusive filling defect (Video 4-5) (7). Also the hepatofugal blood flow in portal vein branches may be seen.

Therapeutic management of caval and hepatic veins complications depends on the time of the presentation and the delay following OLT. In the case of severe allograft dysfunction or multi-organ failure, retransplantation is always indicated. Beyond this particular situation, percutaneous radiological intervention is the method of choice, where mortality after interventional transplant salvage procedure is 11.1% as compared with 41.6% mortality for those patients managed by retransplantation (4).

CONCLUSIONS

Although there is increasing survival of patients after OLT, the risk of complications after surgery persists. Vascular complications are ones of the most common and life threatening complications after OLT. As there are no specific clinical features or laboratory markers imaging plays the main role in making correct diagnosis. Ultrasound is the first line imaging modality for evaluating transplanted liver vasculature as it has good availability and in experienced hands may provide precise diagnosis. Nevertheless in difficult or unclear cases other imaging modalities as CT, MR or DSA should be considered.

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THE SUPERIOR MESENTERIC ARTERY ANATOMICAL FEATURES THAT CAUSE VASCULAR COMPRESSION SYNDROMES

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ABSTRACT

Objective. To evaluate prevalence rate of superior mesenteric artery (SMA) syndrome in CT imaging research carried out in The Hospital of Lithuanian University of Health Sciences Kauno klinikos Department of Radiology.
Materials and methods. Evaluation of 330 patients of abdomen CTs. Advantage Workstation 4.2P (GE HealthCare) was used for multiplanar reconstruction. Statistical analysis was performed with SPSS v. 23.0.
Results and conclusions. Superior mesenteric artery syndrome risk factors were identified: small aortomesenteric angle and decreased aortomesenteric distance with prevalence of 18,2% and 14,3% of cases, respectively. At least one risk factor was prevalent in 25,6%, both in 6,7% of patients. Low origin of SMA was observed in 6,7% cases. Compression of the left renal vein between the SMA and aorta in 24,0% cases: 7,0% of them had radiology signs compatible with Nutcracker syndrome. Identified lower than 10 mm cut-off value with 73% sensitivity and 81% specificity of the distance between SMA and abdominal aorta at the level of left renal vein.

***Keywords*:** vascular compression syndrome, superior mesenteric artery, left renal vein

INTRODUCTION

Because abdominal cavity organs are arranged in confined anatomic space, various anatomical structures can compress blood vessels, or arteries of harder consistency can compress internal organs. When symptomatic, such compressions are referred as " vascular compression syndrome" (VCS), since they all involve either the compression of vascular structures or the compression of hollow viscera by vascular structures [1].
Physicians of various specialties can come across this syndrome, but often due to vague, nonspecific, and obscure symptoms, correct diagnoses maybe delayed or even missed. Although the prevalence rate of VCS in population is less than 1 pct, it is important to be able to recognize and properly examine patients if the syndrome can be suspected. Literature mentions various types of VCS [1, 2]. In this article we are going to discuss two of them: superior mesenteric artery (SMA) and nutcracker syndromes.
SMA syndrome occurs when the third part of the duodenum is compressed between SMA and the abdominal aorta (AA). At the vertebral L1-L2 level SMA branches from abdominal aorta and travels in an anterior/inferior direction making an angle with abdominal aorta (SMA angle). Right here, in the level of L3 vertebral between SMA and AA occurs the third (inferior/horizontal) part of the duodenum. Duodenum is almost entirely retroperitoneal and surrounded by retroperitoneal fat, which helps to maintain big SMA angle and distance between SMA and AA. According to literature data, normal SMA angle is between 28°– 65°, and distance between SMA and AA is 10 to 35 mm [3-6]. These measurements can decrease because of rapid and severe weight loss, resulting in a loss of retroperitoneal

fat, for example in cases of cancer, eating disorders or malabsorbtion [7, 8]. Also after undergoing corrective surgery for scoliosis, in whom lengthening of the spine may increase tension on the SMA and thus decrease SMA angle and aortomesenteric distance [9, 10]. Risk may increase because of anatomical variance such as low origin of the SMA [8, 11].

Syndrome resembles upper-gastrointestinal-tract obstruction symptoms: heaviness after eating, nausea, vomiting, weight loss. An important feature in classical syndrome case - symptoms are partially relieved when lying flat in the face down or on the left lateral position [3, 7, 8]. Diagnosis must be reached by exclusion of other gastrointestinal-tract obstruction causes performing esophagogastroduodenoscopy and imaging methods. In nonoccurrence of other disorders related to symptoms, CT angiography, which is gold standard diagnostic test for SMA, is performed. In arterial contrast phase images are reconstructed for clear visual evaluation of SMA angle and distance between SMA and AA (fig. 1). It is important to note that the radiologic findings of these symptoms alone are not sufficient to make the diagnosis of SMA syndrome, unless clinical symptoms are also present [1].

Firstly SMA syndrome is treated symptomatically. The main conservative long term treatment method is weight gain, to increase the SMA angle [8]. If these methods are ineffective, the possibility of surgery is considered. First choice surgical option includes laparoscopic duodenojejunostomy [12, 13].

Nutcracker syndrome (NS) first time was mentioned in 1937, when authors described the position of the left renal vein (LRV) between SMA and the aorta as being similar to that of a nut between the jaws of a nutcracker [14]. Most typically LRV is compressed between SMA and the aorta and is known as anterior nutcracker. In atypical cases retroaortic or circumaortic renal vein may be compressed between the aorta and the vertebral body, which is called posterior nutcracker. As in the case of SMA compression this anatomical variance of syndrome is not always associated with clinical symptoms. In rare cases when symptoms occur, this condition is called NS. NS origin is analogous to and may occur simultaneously with SMA syndrome [15, 16].

Clinical manifestation of the nutcracker syndrome includes left flank pain, haematuria, orthostatic proteinuria. Severity of symptoms can vary - gross haematuria can result in anemia. Because of pelvic venous congestion, chronic pelvic pain, dysuria, dysmenorea can occur in women and left side varicocele in men [19-22]. NS is very rarely the cause of haematuria, so at first it is necessary to exclude other diseases. Usually NS is diagnosed by performing CT angiography in venous phase. In reconstructed images SMA angle and distance between SMA, the aorta and dilated LRV and pelvic vein is evaluated (fig. 2 and 3). Ultrasonography can help to evaluate peak systolic velocity (PSV) in LRV compression point and renal hilum. The ratio of the PSV between the two measured points is called velocity rate. The optimum cut-off values must be equal or greater than 4.7 (sensitivity 100%, specificity 90%) for NS diagnosis [23]. Still the most informative diagnostic test for nutcracker syndrome remains retrograde venography. Test allows to determine the renocaval pressure gradient, the dilated gonadal and other pelvic veins. Clinical NS diagnosis should be made when observations of LRV compression at multidetector CT or MR imaging with characteristic clinical symptoms are present. The absence of symptoms merely represents the nutcracker phenomenon, not nutcracker syndrome [1].

The main goal in conservative treatment is weight gain. Surgical option is considered, if very severe clinical symptoms occur. To alleviate LRV outflow obstruction and hypertension numerous surgical approaches can be used: LRV transposition to the more inferior vena cava (IVC), LRV bypass surgery, external venous stent placement, renal autotransplantation to the iliac fossa [15, 21,24].

To draw attention to these quite rare syndromes, we performed retrospective analysis of prevalence rate of SMA anatomical features causing VCS, in CT imaging research carried out in The Hospital of Lithuanian University of Health Sciences Kauno klinikos Department of Radiology.

OBJECTIVE: To evaluate the prevalence rate of SMA anatomical features causing VCS, in CT imaging research carried out in The Hospital of Lithuanian University of Health Sciences Kauno klinikos Department of Radiology.

MATERIALS AND METHODS

Retrospective analysis of abdominal CT scans. The study sample consisted of patients who had undergone abdominal CT scan examinations in January - March, 2016 in the department of Radiology in The Hospital of Lithuanian University of Health Sciences Kauno klinikos. 330 patients reconstructed abdominal CT scans were evaluated (N=330), men 157 (47,6%) and women 173 (52,4%). Average age 60,2 ± 15,0.

CT imaging tests were performed using "GE Light Speed VCT 64" multidetector computed tomography on the patients lying on their back with hands raised above their heads. We performed non-contrast and contrast scan in craniocaudal direction using non-ionic intravenous contrast agents. Using automatic syringe we injected 100 - 120 ml contrast material at the 3 ml per second velocity. CT imaging was performed after 30 and 55s after contrast injection. We evaluated 330 patients' abdominal CT using Advantage Workstation 4.2P for multiplanar reconstruction. We evaluated these anatomical peculiarities: SMA angle, distance between SMA and abdominal aorta at the level of the duodenum and LRV . We measured the height were SMA branches from AA near vertebral cortex level, and evaluated hemodynamic changes characteristic for NS - LRV prestenotic dilatation, renal and pelvic varicose veins. CT scans were not analyzed in cases where it was not possible to examine and evaluate investigated structures. For data analysis we used descriptive statistics, means were presented with standard deviation. A nonparametric Mann-Whitney test was used to compare the means of the quantitative variables for the two independent groups. ROC (Received Operating Characteristic) analysis was used to determine the sensitivity and specificity of the study, and diagnostic value. The results are considered statistically significant if $p < 0,05$.

RESULTS

Average SMA angle - 47,5 ± 4,6°. Less than 28° angle, which is risk factor for SMA syndrome, was found in 60 (18,2%) subjects, bigger - 270 (81,8%). Average distance between SMA and AA was 20,50 ± 1,15 mm. Less than 10 mm distance is risk factor for SMA syndrome and was found in 47 (14,3%), bigger than 10 mm - 281 (85,7%) cases. In 2 (0,6%) subjects duodenum was in front of SMA. At least one risk factor was found in 84 (25,6%) patients, two - 22 (6,7%). There were no correlation between SMA angle and the distance to AA ($r = 0,48$, $p = 0,01$). Men average SMA angle is bigger than women (52,9 ± 21,5° ir 42,6 ± 19,4°, $p = 0,01$). Men average distance between SMA and AA was larger than women (42,6 ± 19,4 mm ir 18 ± 10 mm, $p = 0,01$). Height were SMA cuts off from AA: in 187 (56,7%) subjects branching occurs at L1 vertebral body level, 79 (23,9%) - at the level of the L1/L2 intervertebral disc, 39 (11,8%) - at Th12/L1 level, 22 (6,7%) - lower than the L1/L2 intervertebral disc, 3 (0,9%) - higher than Th12/L1 intervertebral disc level (diagram 1). LRV compresion was found in 79 (24,0%) subjects. 23 (7,0%) had radiological signs/indications characteristic of NS - LRV prestenotic dilatation, renal and pelvic varicose veins (diagram 2). Insignificant LRV prestenotic dilation was present in 56 (17,0%) subjects. The NS was not evaluated in 16 (4,8%) subjects because of their anatomical features (LRV was positioned behind AA). Average distance between SMA and AA at LRV was 15,4 ± 1,0 mm.

Using ROC curve analysis AUC = 0,801, we determined critical distance between SMA and AA at LRV which is smaller than 10 mm, with 73% sensitivity and 81% specificity.

DISCUSSION

There are limited literature data about VCS and the amount of research subjects in published studies is quite small. According to many authors the normal distance between SMS and AA is 10-35 mm, and <8-10 mm is considered as SMA risk factor. On the other hand, data about SMA angle size as risk factor are ambiguous. Many sources refer to <25° or <22° angle, but

we in our study used newer data which point out <28° angle [3-7]. Italian researches performed untrasonography on 950 patients and found significantly reduced SMA angle (<25°) in 3,05% (N=29) cases. 22 patients also had reduced distance between SMA and AA - from 2 to 8 mm. CT examinations gave overlapping results [25]. These results differ from our analysis - we found 18,2 % reduced SMA angle and 14,3% reduced distance between SMA and AA, respectively. The distinction may be caused by selecting different research methods (untrasonography and CT) and bigger SMA angle margins. N. D. Marret and co-authors specify SMA angle values for 8 SMA syndrome patients between 9° and 18° (average/mean 12°) in their research paper [7]. G. A. Agrawal and co-authors who analyzed 4 SMA syndrome cases found similar results - average SMA angle in CT reconstruction was 13,5° and distance between SMA and AA - 4,4 mm [3].
We did not found literature data about prevalence rate of LRV compression or NS radiological characteristics but discovered information about the meanings of such attributes. According to W. J. Fu and co-authors research of NS patients data, average distance between SMA and AA was 3 mm, while control group data - 10-14 mm [17]. Arima M. and co-authors in the group of patients found smaller than 16° SMA angle [18].

SMA syndrome and NS are more prevalent in women than men patients [3, 7, 8, 19-22]. Our research data shows that the distance between SMA and AA and the average SMA angle were smaller in women than men, which could indicate relatively higher risk of these syndromes.
As the use of CT increases, symptoms of vascular compression syndrome (VCS) are sometimes detected in the patients for research on a completely different basis. In these cases, when characteristic clinical symptoms are not present, the situation is described as radiological signs of vascular compression or radiological syndrome. It is important to keep in mind that when a patient is undergoing a CT scan of abdominal pain and we cannot identify any obvious changes, there is always a need to think about VCS.

CONCLUSIONS

1. The prevalence rate of SMA syndrome risk factors indentified: SMA angle less than 28° - 18,2 %, distance between SMA and AA less than 10 mm - 14,3 %, Low SMA branching position from the abdominal aorta - 6,7 % patients.
2. 7,0 % of patients had radiology signs compatible with NS.
3. Identified lower than 10 mm. cut-off value with 73 % sensitivity and 81 % specificity of the distance between SMA and abdominal aorta at the level of left renal vein.

Figure 1. Patient R. K. Abdominal CT scan examination using intravenous contrast agents. Sagittal view of SMA (red arrow) and compressed duodenum (blue arrow).

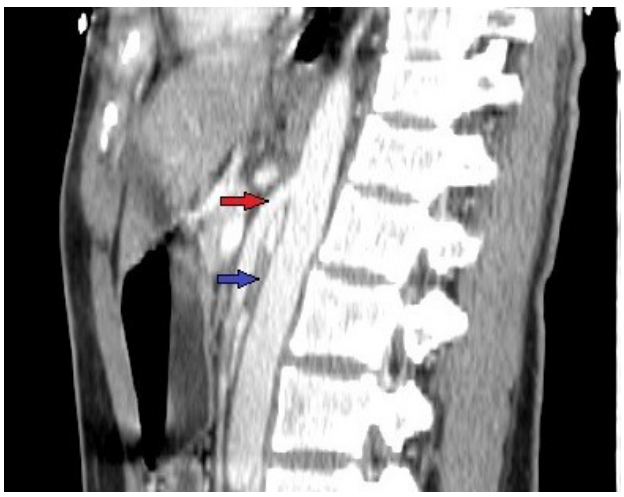


Figure 2. Patient R. K. Abdominal CT scan examination using intravenous contrast agents. Axial view of SMA (red arrow) and dilated LRV (blue arrow).

Figure 3. Patient R. K. Abdominal CT scan examination using intravenous contrast agents. Axial view of dilated pelvic veins indicated by red arrows.

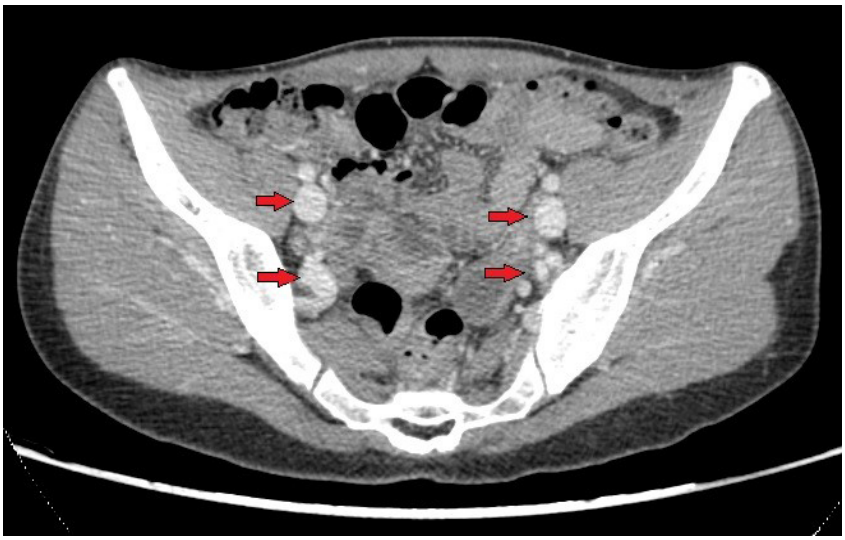


Figure 4. The prevalence rate of SMA syndrome risk factors.

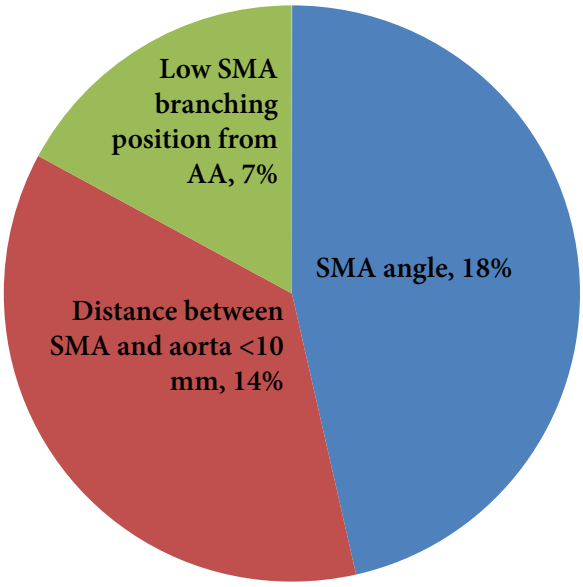
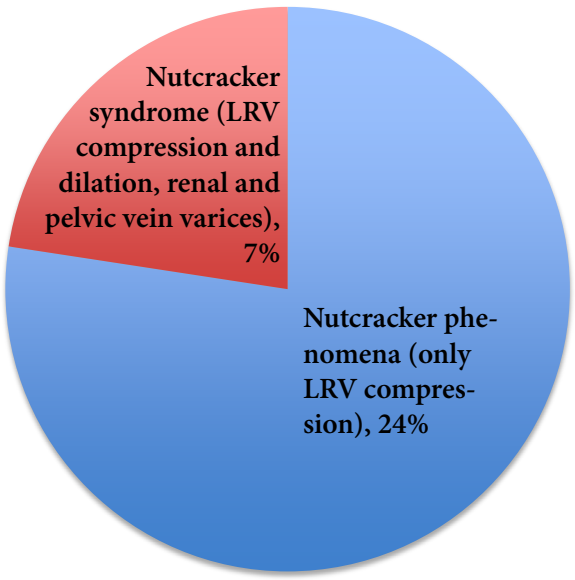


Figure 5. The prevalence rate of NS risk factors.



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RADIOGRAPHERS' JOB SATISFACTION: CROSS-SECTIONAL SURVEY IN LITHUANIA

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ABSTRACT

Background: Job satisfaction has become an important issue for healthcare organizations in recent years, because of potential labor shortages, their effect on patient care. Job satisfaction has a great influence in healthcare specialist retention and the delivery of high quality care. Rapid changes in of radiology services have placed more interest on radiographer's who will face not only all peculiarities of healthcare specialists' work, but also an increased physical risk, especially exposure to ionizing radiation, which highlights the importance of analyzing various aspects of these specialists' working conditions and job satisfaction.

Purpose: To evaluate radiographers' job satisfaction.

Materials and methods: The study was conducted using an original P. E. Spector's (1994) Job Satisfaction Survey. The instrument consists of the following subscales: Pay, Promotion, Supervision, Fringe Benefits, Contingent Rewards, Operating Procedures, Coworkers, Nature of Work, and Communication. The score of each subscale ranged from 4 to 24 points, and the total score – from 36 to 216 points. A greater score indicates greater job satisfaction. The study involved in all 127 respondents.

Results: The majority of the studied radiographers demonstrated moderate job satisfaction – the total job satisfaction score was 123.51±16.4 points. The highest job satisfaction scores were observed in the Communication (20.8±3.8 points), Nature of Work (18.1±3.9), and Supervision (16.5±4.1 points) subscales, and the lowest – in the Pay subscale (7.7±3.9 points). Other causes of poor job satisfaction included an unclear system of Contingent Rewards (10.2±4.3 points) and Operating Procedures (10.4±3.8 points). Participants younger than 26 years of age were more satisfied with their work, compared to their older colleagues ($p<0.05$), and widows were more dissatisfied than singles ($p<0.05$). The study showed that greater work experience negatively affected radiographers' job satisfaction ($p<0.05$).

Conclusions: The concept of job satisfaction is associated with employees' attitudes, emotions, feelings, and the satisfaction of their needs at work. The studied radiographers' overall job satisfaction was moderate. The radiographers' greatest job satisfaction was associated with communication, nature of work, and supervision, and the poorest – with pay, an unclear system of contingent rewards, and current operating procedures. The highest job satisfaction scores were observed in younger singles with higher education. Job satisfaction dropped with increasing work experience.

Keywords: radiographer, job satisfaction, survey

INTRODUCTION

Job satisfaction is an important aspect for a person as well as for an organization. This is a very broad concept that encompasses multiple aspects of a job, and thus creation of a single common definition is complicated. Job satisfaction is an integral value composed of satisfaction with various objects, subjects, and phenomena of the job. In addition, this value is ever-changing [1]. A survey of the definitions of job satisfaction found in scientific literature revealed three aspects of the definitions: an employee's attitudes, emotions, feelings, and the satisfaction of his or her needs at work [2-4]. Thus, the concept "job satisfaction" reflects an employee's positive attitudes towards his or her work, the satisfaction of his or her needs, and the resulting positive effect. Employees' job satisfaction is important for ensuring an enterprise's productivity, the effectiveness of its activity, and the quality of its services, as well as for retaining good and loyal specialists [5]. Poor job satisfaction may result in weak cooperation and communication links, poor quality of services, hostility, poor health, and high staff turnover [6]. Biological, chemical-physical, and social-psychological factors of the working environment impair professional motivation of healthcare specialists and promote job dissatisfaction [7]. The character of healthcare specialists' work is associated with elevated mental and emotional stress, and thus, according to the Labor Code of the Republic of Lithuania, they have a shorter workweek - 38 (37) hours. However, in Lithuania, personal healthcare specialists for various reasons (mostly, because of low salaries and

a shortage of specialists) work in several places, exceeding the set workload norms and thus violating the work and leisure time regulations and risking their own and their patients' health [8].
According to various researchers, employees who are satisfied with their job more readily immerse in it, have a lower risk of the burnout syndrome, and work more productively and effectively. Job satisfaction depends on various factors, including the nature of the work, the operating procedures, workload, pay, relationships with coworkers, promotion opportunities, and supervision [9, 10]. According to research data, older employees frequently are more satisfied with their jobs than their younger colleagues are [11]. Better education is also frequently associated with better job satisfaction. Researchers have stated that better educated people have more interesting jobs, a greater autonomy, and better possibilities to satisfy their needs [12, 13]. According to various researchers, job satisfaction may be measured globally (overall satisfaction) and through individual aspects, such as working environment and payment, communication and interpersonal relationships, career opportunities, the managers' behavior and organizational activity, etc. [14, 15]. The research instruments for analyzing job satisfaction are distributed into three categories: multidimensional instruments for the evaluation of work in general, multidimensional instruments for the evaluation of concrete jobs, and instruments for the evaluation of job satisfaction via multiple factors [16]. Healthcare specialists' work requires much internal emotional and physical effort, and thus these specialists' job satisfaction is extensively analyzed in order to identify the main factors that affect job satisfaction, which would help to ensure a more favorable psychological climate and a better quality of the provided services [17]. Radiographers face not only all the peculiarities of healthcare specialists' work, but also an increased physical risk (especially exposure to ionizing radiation), which highlights the importance of analyzing various aspects of these specialists' working conditions and job satisfaction.

AIM OF THE WORK

To evaluate radiographers' job satisfaction.

MATERIALS AND METHODS

In order to evaluate radiographers' job satisfaction, we applied a quantitative research technique – a questionnaire-based survey. Non-probability purposive sampling was used for the study. The study included radiographers from various towns and cities of Lithuania irrespectively of their membership in the Lithuanian Association of Radiographers. The study was conducted on February 24, 2017, during the Assembly of the Lithuanian Association of Radiographers. In total, 150 questionnaires were distributed, of which 131 were returned. Four questionnaires were filled out incorrectly and thus were excluded from further analysis. The response rate was 87%. During the study, the requirements for confidentiality and anonymity were observed. In total, 127 radiographers participated in the study. All the participants (100%) were females. The largest age group (59.1%) consisted of 46-65 year-old radiographers. In addition, 68.5% of the participants were married or were living with a partner, and nearly one-half (48.0%) of the radiographers had post-secondary non-tertiary education level (Table 1).
To evaluate radiographers' job satisfaction, was used P. E. Spector's (1994) Job Satisfaction Survey (JSS). The instrument consists of 36 items evaluated by the respondents on a six-point scale, where 1 point means "strongly disagree", 2 points – "moderately disagree", 3 points – "partly disagree", 4 points – "partly agree", 5 points – "moderately agree", and 6 points – "strongly agree". The following aspects of the job were evaluated: pay, promotion opportunities, supervision, fringe benefits, operating procedures, work organization, coworkers, nature of work, and communication at work. Each of the nine subscales was evaluated by 4 statements. The sum score of each subscale ranged from 4 to 24 points, and the total score - from 36 to 216 points. Higher scores indicated better job satisfaction. To evaluate the internal consistency of the scale, Cronbach's alpha coefficient was used. Cronbach's alpha coefficient in the evaluation of the internal consistency of Spector's instrument was 0.899, which indicates high internal consistency and reliability of the JSS.

STATISTICAL ANALYSIS

Statistical data analysis was conducted by applying the statistical data storage and analysis software package SPSS v. 19. The level of significance selected for testing data points was established at $p \leq 0.05$, meaning that the difference was statistically significant. at $p \leq 0.001$ –statistically highly significant. Descriptive statistics was used to calculate the mean values of the variables within a 95% confidence interval. The normality of the distribution of quantitative variables was evaluated by using the Kolmogorov-Smirnov test. The mean values of the parametric variables of two independent samples with distribution that was not statistically significantly different from normal were compared by applying Student's t-test, and the mean values of parametric variables of more than two independent samples were compared by using the ANOVA test and the LSD post hoc criterion. The strength of the relationships between the characteristics was evaluated by calculating Pearson's correlation coefficient (r). If $0<|r|\leq 0.3$, the values were weakly interdependent, if $0.3<|r|\leq 0.8$, they were moderately interdependent, and if $0.8<|r|\leq 1$, they were strongly interdependent. The correlation coefficient is positive when one value increases together with the other, and negative – when with an increase in one value, the other will decrease.

RESULTS

During the study, we evaluated individual aspects of job satisfaction, distributed into nine subscales. The study showed that radiographers attributed the highest job satisfaction scores to communication (20.8±3.8 points), the nature of work (18.1±3.9), and supervision (16.5±4.1 points). The lowest job satisfaction score was observed in the Pay subscale – on the average, 7.7±3.9 points. Other aspects associated with poor job satisfaction were an unclear system of contingent rewards (10.2±4.3 points) and operating procedures (10.4±3.8 points) (Figure 1).

The study showed that the mean total job satisfaction score was 123.51±16.4 points, which means that the majority of the radiographers were moderately satisfied with their job. The lowest total job satisfaction score was 74 points, and the highest – 187 points.

The evaluation of overall job satisfaction among radiographers of different age groups showed that respondents younger than 26 years of age were more satisfied with their job, compared to their older colleagues (p=0.011) (Figure 2).

In this study, we also evaluated overall job satisfaction depending on the respondents' marital status. The obtained results showed that widows were least satisfied with their job – which was shown by statistically highly significantly lower job satisfaction scores, compared to those provided by singles (p=0.001) (Figure 3).

The analysis of overall job satisfaction depending on the respondents' education level showed that radiographers with post-secondary non-tertiary education were less satisfied with their job, compared to college or university graduates (p=0.036) (Figure 4).

The results of our study showed that the greater the radiographers' work experience was, the less they were satisfied with their job. A statistically significant albeit weak negative correlation was observed between the respondents' overall job satisfaction and their work experience (r= -0.296, p=0.010) (Figure 5).

In general, the results of the study showed that the radiographers who participated in the study were moderately satisfied with their job – the highest score of an individual aspect of job satisfaction was only 20.6 points out of the maximum of 36. Satisfaction with the pay was especially poor – it barely exceeded the lowest possible score. The results of the analysis depending on the respondents' age, workload, and position showed that the respondents were most satisfied with relationships with their coworkers. Unfortunately, job satisfaction decreased with increasing work experience.

DISCUSSION

Healthcare specialists' work requires much internal emotional and physical effort, and thus these specialists' job satisfaction is extensively analyzed in order to identify the main factors that affect job satisfaction, which would help to

ensure a more favorable psychological climate and a better quality of the provided services. The analysis of various scientific studies showed that most research focuses on nurses' job satisfaction, whereas studies on radiographers' job satisfaction can hardly be found. For this reason, this evaluation of radiographers' job satisfaction indicates the practical novelty of the topic.

To evaluate radiographers' job satisfaction, we used P. E. Spector's (1994) Job Satisfaction Survey (JSS) designed for the evaluation of overall job satisfaction and its nine aspects. The study showed that most radiographers were moderately satisfied with their job. A similar level of job satisfaction was found in a study on the characteristics of nurses' internal motivation for professional activity and their job satisfaction. The total job satisfaction score in P. E. Spector's Job Satisfaction Survey among nurses was also moderate and reached 123.7 points [6].

Similar results were obtained by other researchers who analyzed various aspects of radiographers' and other healthcare specialists' job satisfaction. A study on nuclear medicine technologists' job satisfaction also showed that the specialists were most satisfied with their relationships, and least satisfied with their pay [17]. Similar results were obtained in a study by Stterfield (2015): employees of the Faculty of Radiology were most satisfied with supervision and relationships with coworkers, the nature of the work and communication, and were dissatisfied with working conditions (operating procedures) and pay [18]. Thus, the results of this study confirm the assumption that healthcare specialists' salaries are a relevant issue and the most common cause of dissatisfaction with their job, whereas relationships with coworkers are most frequently evaluated as a factor that results in the greatest job satisfaction.

Our study showed that younger radiographers were more satisfied with supervision, relationships with coworkers, and fringe benefits, whereas 46-65 year-old respondents more favorably evaluated the probability of contingent rewards. These results differ from statements found in scientific literature indicating that older employees are more satisfied with their job than the younger ones because of their greater competence, professionalism, and lower ambitions and requirements for the job [11, 13].

The employees' marital status is one of the independent factors that affect job satisfaction. According to various research data, job satisfaction depends on whether the employee is living with a partner or alone. Our results are in line with those of other studies, showing that married or cohabiting women were more satisfied with their relationships with coworkers, supervision, and the nature of the work [6, 19].

Education is another factor that affects employees' job satisfaction. In this study, we evaluated job satisfaction among radiographers with different education background and detected statistically significant differences. Respondents with post-secondary non-tertiary education were less satisfied with supervision and relationships with coworkers, compared to radiographers with higher university-level education. These results corroborate the statement found in scientific literature indicating that better education frequently results in better job satisfaction [20].

Various scientific studies have analyzed the associations between job satisfaction and work experience. The results of those studies indicate that satisfaction with the job or its various aspects increases with increasing work experience. For instance, research on nurses' job satisfaction showed that nurses with greater work experience (over 21 years of service) were more satisfied with their professional activity [6]. However, the results of our study showed that the greater the radiographers' work experience was, the less they were satisfied with their job.

CONCLUSIONS

A survey of scientific literature showed that the concept of job satisfaction is associated with employees' attitudes, emotions, feelings, and the satisfaction of their needs at work.

The results of the study showed that the radiographers' overall job satisfaction was moderate.

The radiographers' greatest job satisfaction was associated with communication, nature of work, and supervision, and the poorest – with pay, an unclear system of contingent rewards, and current operating procedures.

The highest job satisfaction scores were observed in younger singles and in radiographers with higher non-university or university-level education. Job satisfaction dropped with increasing work experience.

Table 1. Socio-demographic characteristics of the respondents.

	Sociodemographic characteristics	n	%
Age groups	<26 years	9	7.1
	26-45 years	38	29.9
	46-65 years	75	59.1
	>65 years	5	3.9
Marital status	Married/cohabiting	87	68.5
	Single	19	15.0
	Divorced	17	13.4
	Widowed	4	3.1
Education level	Post-secondary non-tertiary	61	48.0
	Higher non-university	43	33.9
	Higher university	23	18.1

Figure 1. Scores of individual subscales of the Job Satisfaction Survey (m±SD).

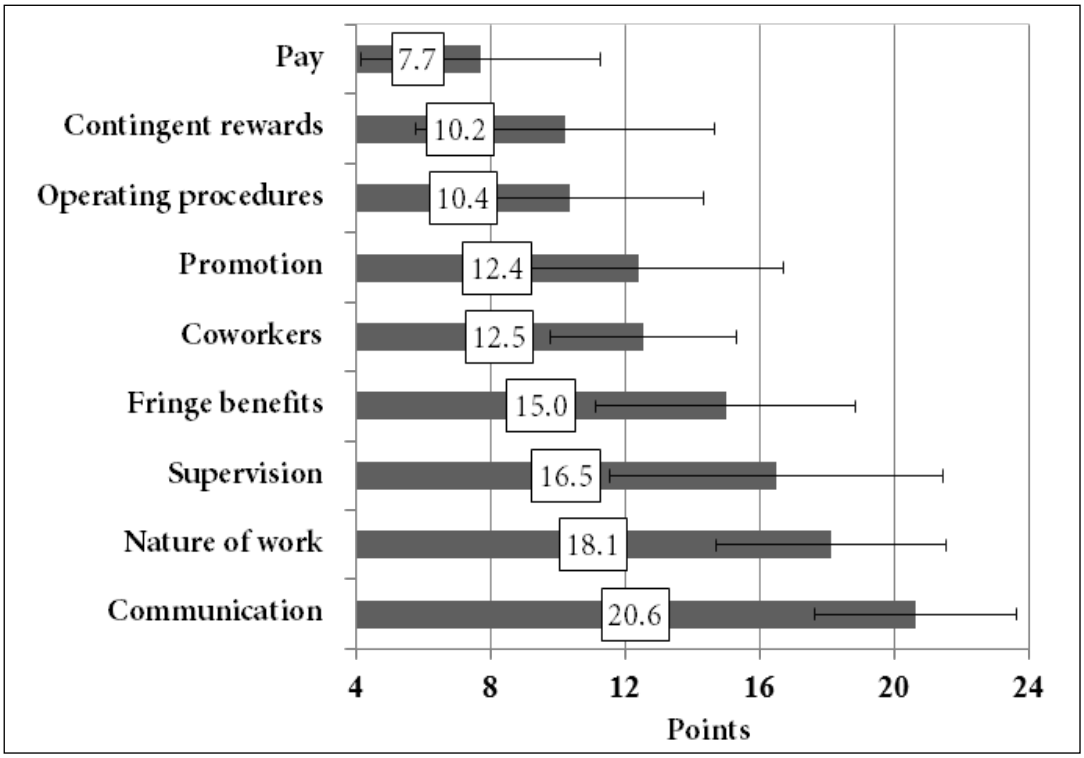
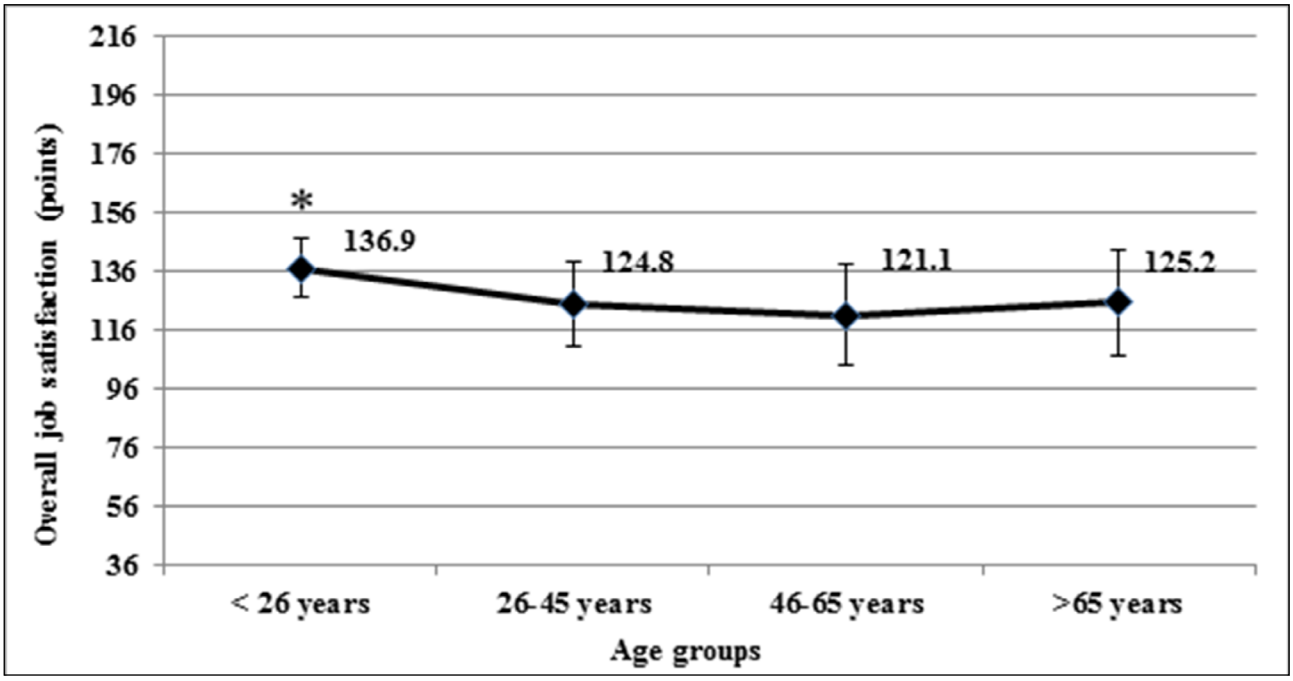
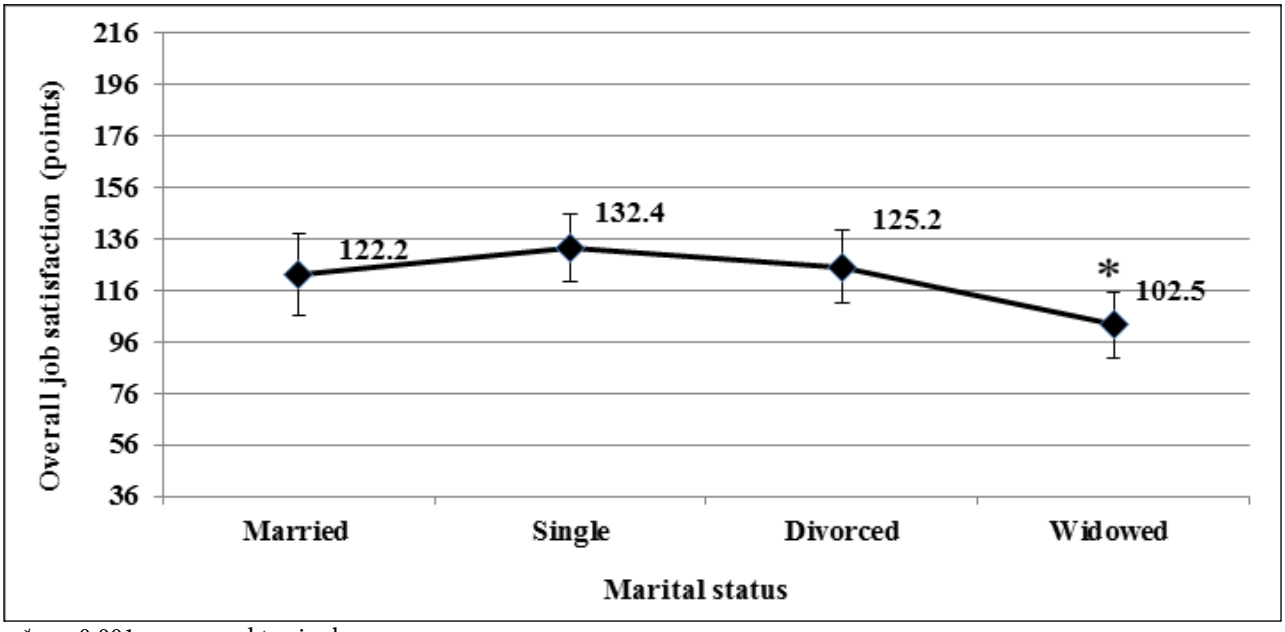


Figure 2. Associations between the subjects' overall job satisfaction and age (m±SD).



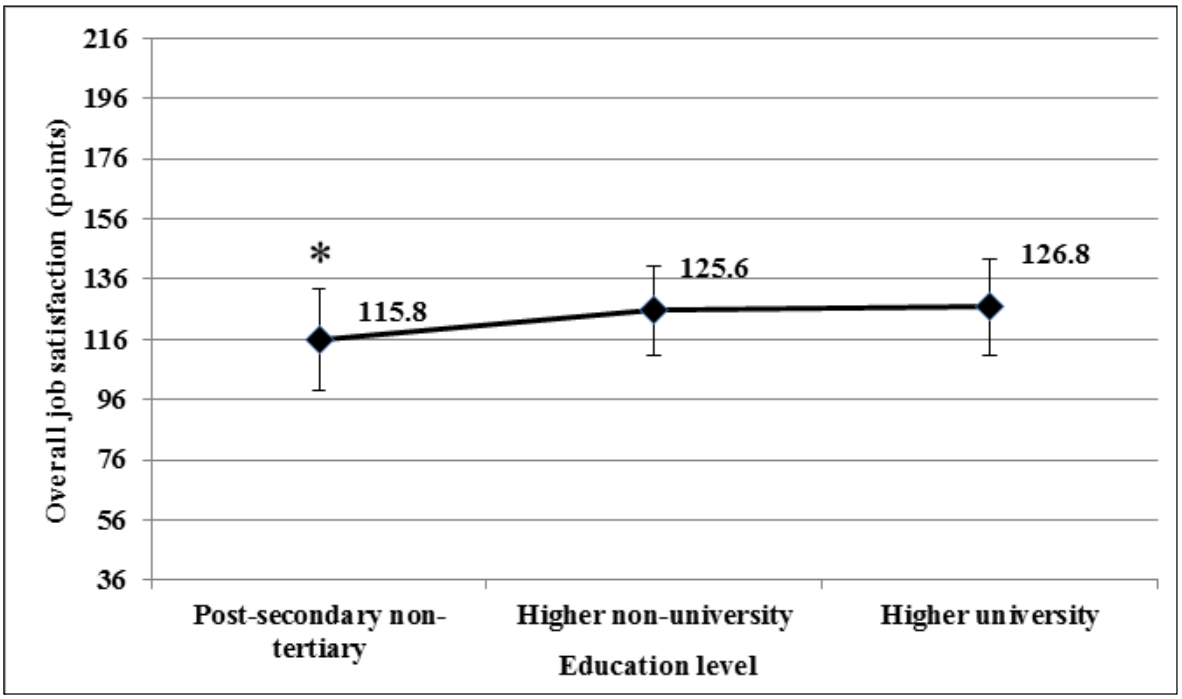
- p<0.05, compared to older subjects

Figure 3. Associations between the subjects' overall job satisfaction and marital status (m±SD).



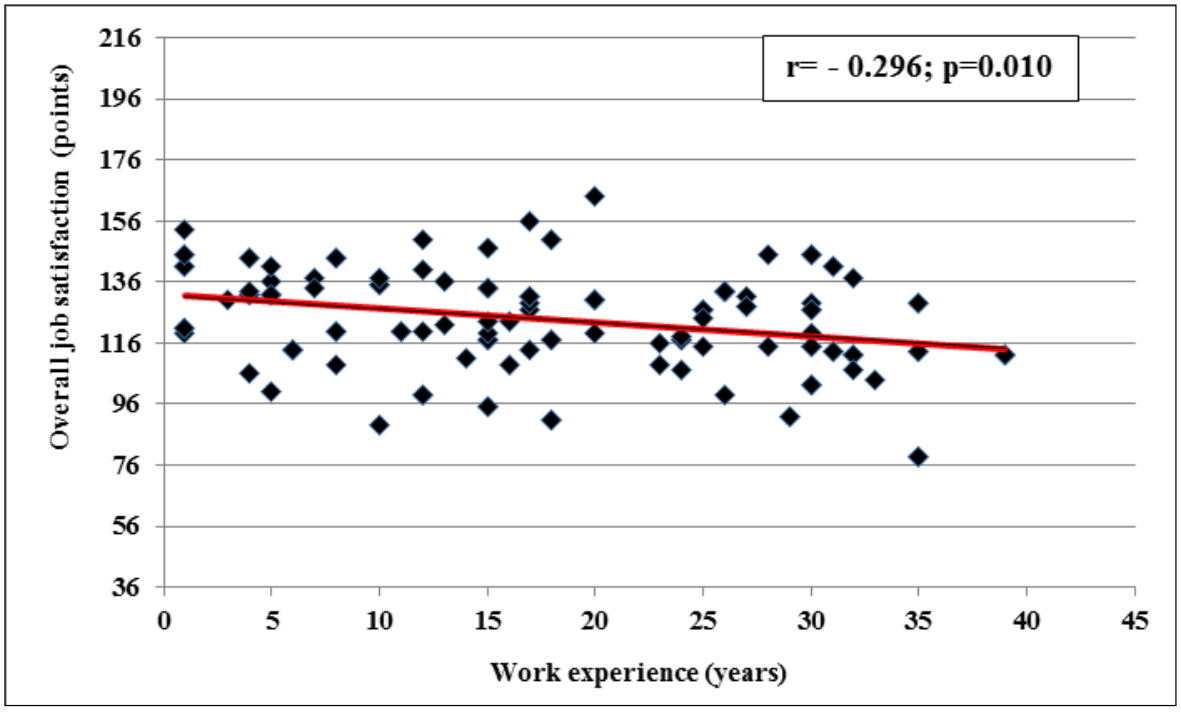
*- p<0.001, compared to singles

Figure 4. Associations between the subjects' overall job satisfaction and education level (m±SD).



*- *p<0.05, compared to those with higher education*

Figure 5. Associations between the subjects' overall job satisfaction and work experience (Pearson's correlation).



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MEDICAL STAFF AND COMMUNITY KNOWLEDGE ABOUT IONIZING RADIATION

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ABSTRACT

Background and aim. Imaging tests become one of the main human-made ionizing radiation sources in these days. Computed tomography (CT) performed within one year could cause more than 29,000 oncological diseases in the future. Further, high dose of radiation could cause acute sickness, infertility or immune system suppression. It is always important to know community and medical staff knowledge level of radiation to improve the current situation.
Methods. Questionnaire was prepared by researchers using published data in this field. The ratio of correct answers to all questions was converted to the percentage and data was processed by using SPSS 24 (Mann Whitney, Pearson Chi square, Kruskal-Wallis tests).
Results. 184 volunteers were surveyed. The average of respondents results was 67.5 %. The average of correct answers in female group was 66.4% and in male group was 70.9%. Knowledge of female and male did not show statistically significant difference. 75.5% know that X-ray involve radiation and 69.6% of participants know that CT involve it as well. Respondents related to radiology and medical physicians statistically had equal knowledge level. Also, 50.0% of respondents were informed or had information about radiation before radiological tests from different sources. There was no statistically significant difference between subjects who were informed about medical radiation and those who were not informed.
Conclusions. There is no difference between females and males, medical physicians and radiologists, informed and uninformed persons knowledge about ionizing radiation. 75.5% know that X-ray involve radiation and 69.6% of participants know that CT involve it as well. Unfortunately, half of participants state that never were informed about ionizing radiation.

Keywords: ionizing radiation, knowledge, patients knowledge, physicians knowledge

INTRODUCTION

Nowadays imaging tests are available every day and medical and dental X-rays become one of the main man-made radiation sources. Based on published reports near 80% of radiation came from natural sources [1], while in Lithuania in 2015 only 70% of ionizing radiation came from nature. One of the main causes of increased medical radiation is growing number of computed tomography (CT) procedures. In our country 55% of total patients exposure (collective effective dose) is determined by exposure associated with CT [2]. Researchers suggesting that for example the CT scans performed in the United States in 2007 might produce more than 29,000 oncological diseases in the future. Breast, lungs, brain cancer could be consequences of radiation. Unfortunately from 5% to 30% of these procedures still may be medically unnecessary [3]. Other dilemma remains that patients are often uninformed about CT ionizing radiation [4]. Nondisclosure of information is one of the problems in the doctor-patient communication. Specialists highly recommend involving patients in treatment and diagnostic process because it increases positive view of their health status, which may influence their health outcomes [5].
Female gender and young age are risk factors for exposure to ionizing radiation adverse effects [6]. It could cause acute sickness, cataract, skin erythema, infertility for men and for women or bone marrow suppression [1, 7]. High dose of radiation is dangerous to pregnancy. Prenatal

death, delayed growth, future mental retardation and an increased risk of cancer are adverse effects to the embryo. The effect depends on the radiation dose and gestation period [7]. Magnetic resonance is also imaging test but it is producing images without the use of ionizing radiation. Despite this fact it could cause some side effects too. Wires, pulse oximeters, analgesic patches, cardiorespiratory monitors, tattoos or other metallic objects could be the reason of thermal burns during this procedure [8]. It is important to discuss these risks with patients before each of the tests. Based on all this data our study aims were to identify community knowledge about ionizing radiation and how did they get information about it.

MATERIALS AND METHODS

The study was conducted in Lithuanian university of health science, Kaunas, Lithuania from December 2016 to July 2017. We prepared questionnaire using published data from other researchers in this field. Participants were asked their profession, education, incidence of having X-ray, CT, magnetic resonance imaging (MRI), ultrasound (US) and their knowledge about ionizing radiation. All participants were classified in three groups- radiology related, doctors and radiology unrelated persons. Physics, radiographers, radiology technicians were considered as radiology related people. Medical students and doctors were considered as doctors and any other specialty having people were considered as radiology unrelated. For each question about radiation answered correctly we counted 1 point. Then we counted ratio: how many questions were answered correctly comparing to potentially answered all questions. The ratio of correct answers to all questions was converted to the percentage. Data was processed by using SPSS 24 (Mann Whitney, Pearson Chi square, Kruskal-Wallis tests). The results were considered as statistically significant, where $p < 0,05$.

RESULTS

184 volunteers were surveyed. 75.5% of them were females and 24.5% of them were males. 4 (2.2%) responders answered their educational level was general basic, about half of participants (51.6%) had secondary education, 17 (9.2%) higher education and 68 (37%) had higher education of university. 21.2% volunteers answered they were radiology related, 17.4% were doctors and 60.9% were radiology and medicine unrelated (Table 1). Knowledge of responders was counted by assessing answered questions from given questions. This number was converted to percentage and the average of their results was 67.5 %, standard deviation ±15.3%. Minimal result was 30.4% and maximal result was 96.6%. The average of correct answers in female group was 66.4% (30.4% - 93.1%) while male answered 70.9% questions correctly on the average (30.4% - 96.6 %). Knowledge of women and men did not show statistically significant difference.

139 subjects (75.5%) know that X-ray involve radiation and 128 (69.6%) of participants know that CT involve it too. 30.4% of respondents incorrectly answered that MRI and 6.0% of respondents incorrectly answered that US could involve radiation. 60.7% persons stated CT as highest exposure of radiation. Also, 93.5% of participants correctly answered about radiation effect to the embryo and 76.1% of all subjects know about radiation and cancer association (Table 2).

Radiology related persons answered 74.5% of questions right on the average (55.2% - 93.1%). The average of doctors correct answers was 76.7% (48.3% - 93.1%). People who specializes other than radiologists, radio technologists or physics and medical doctors answered 62.4% of questions on the average (30.4% - 96.55%). Radiology related and medical doctors had equal knowledge level (p=0.389). Radiologists, radiology technologists or physics and medical doctors had statistically significantly better knowledge than people claiming their specialty was "other than that".

50.0% of respondents were informed about radiation before radiological tests from different sources (Figure1). 9 of study participants had more than one source of information. There was no statistically significant difference (p=0.718) between subjects who were informed about medical radiation and those who were not in-

formed. Informed respondents answered 70% on the average (44,8% - 96,5%) and those who were not informed answered 70,8% correctly on the average (41,4% - 93,1%).

DISCUSSION

Radiologists, clinicians and other people have exposure to ionizing radiation. To create safe environment it is important to evaluate all community knowledge about it. Lee RK et al. [4] compared radiologists and non-radiologists knowledge about radiological investigations. Radiologists had better knowledge about radiation doses of radiological investigations. None of the non-radiologists right answered about the radiation dose of a chest x-ray while 32% of radiologists knew the right answer. Also, it was noticed that residents of radiology department had better knowledge than senior radiologists. Authors of this publication do not report about statistically significance. There was no statistically significant difference between radiologist and other doctors knowledge in our study. Awosan KJ et al. [1] compared all health workers knowledge of radiation hazards. Imaging specialist, doctors and nurses had better knowledge than administrative and other supporting staff. Also, authors checked sex and knowledge relationship. It was noticed that males had better knowledge than females. Our study did not show statistically significant difference in participants knowledge based on sex. Sin H with colleagues [9] was comparing patient knowledge and did not find correlations between this demographic variable too.

Based on published reports, from 70.0% to 77.6% of patients named CT as ionizing radiation source. Unfortunately, about 60% of subjects still did not know that MRI is radiation free [9, 10]. Our study revealed similar results. Zwank MD et al. [10] published that about half of patients want to get more information about ionizing radiation before imaging test. Usually they are informed by doctors (45.2%-69%) or radiologist (31.3%) [9, 11]. According to our results, half of responders were not informed about radiation before the test at all. 30% of responders were looking for the information about radiation by themselves. In fact, all patients sign agreement before the radiological test is done. Indications, contraindications, hazards of the radiological test are explained in the agreement that is given to the patient to read before the test. Due to the lack of time, some patients are not always informed in detail verbally, but they are always informed in writing. To be more precisely, our research results saying 50% of patients are uninformed show that written information is not always understood or read by patient. Paradoxically, knowledge about radiation was equal of informed and uninformed responders. Despite the effort, community understanding about radiation remains limited so it is important to inform them about tests' risks. Communicating with patients would help them feel more comfortable and would increase the confidence of the doctor [12]. In order to ease doctors work and purify the information they give to their patients, standardized guidelines of what must be said to patient, for example: indications, contraindications, hazards of the test, phone numbers to call if adverse effect happens, should be prepared. To save on doctors time, flyers with this kind of information could be given to every patient in waiting rooms of radiology department. As we concluded that written information is not always read by patients, short movies about radiological tests shown in radiology department waiting rooms would be the option as well. This would help doctors confidently inform patient without fear to forget what must be said or without fair to mislead patient. This would help hospitals to reduce complaints and grievancies about rudeness, negligence and malpractise of personell [13].

Our study revealed that, knowledge about X-ray is sufficient, but there are still 3 from 10 subjects who think that MRI is not radiation-free. There is no difference between females and males, doctors and radiologist, informed and uninformed persons knowledge about ionizing radiation and hazards. Doctors and other staff should spread more necessary information about imaging risks to all the patients independently from their sex or specialty. Finally, we think that spread of information would highly increase the reliance on the medical staff.

Figure.1 Source of information about ionizing radiation

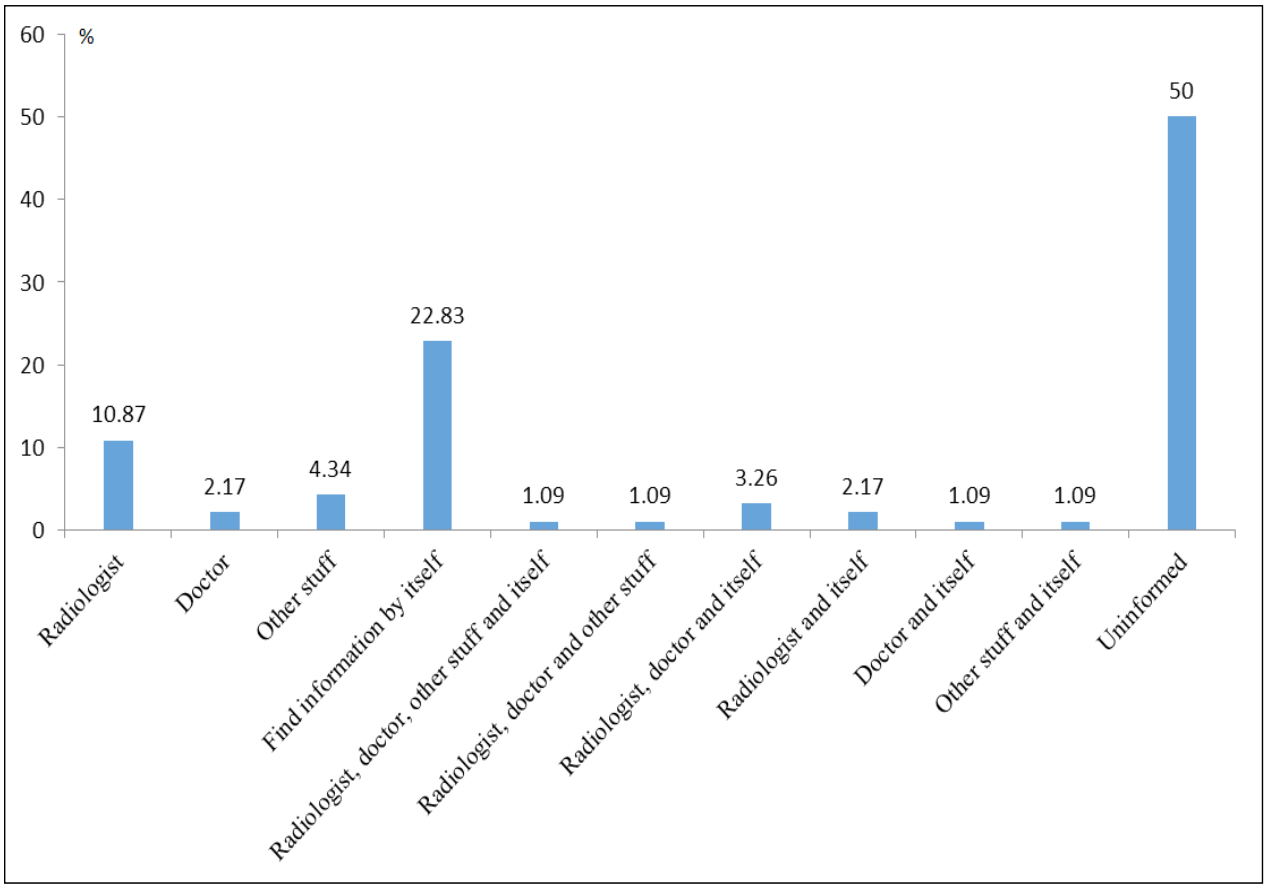

Table 1. Socio-demographic profile of participants.

Characteristics		**Frequency (%)** n = 184	
		n	**%**
Sex	Female	139	75.5
	Male	45	24.5
Specialty	Radiology related	39	21.2
	Doctor	32	17.4
	Other	113	60.9
Education	Primary	4	2.2
	Secondary education	95	51.6
	University	17	9.2
	Higher education of university	68	37.0

Table 2. Correct answers of respondents to questions about radiation

Questions \ Answered	Radiology related people	Doctors	Other specialties
Which test has higher radiation: a) X-ray 60times higher than CT; b) CT 70times higher than X-ray; c) the same?	3 (37.5%)	2 (28.6%)	64 (83.1%)
Does X-ray test use radiation?	37 (94.9%)	30 (93.8%)	70 (63.1%)
Does CT scan use radiation?	37 (94.9%)	30 (93.8%)	59 (53.2%)
Does MRI use radiation?	32 (82.1%)	29 (90.6%)	65 (58.6%)
Does US use radiation?	36 (92.3%)	29 (90.6%)	106 (95.5%)
Which test has the highest amount of radiation?	36 (92.3%)	29 (90.6%)	44 (40%)
Do CT or X-ray damage embryo/fetus?	20 (95.2%)	32 (100%)	34 (87.2%)
Do MRI damage embryo/fetus?	10 (47.6%)	22 (68.8%)	12 (30.8%)
Do US damage embryo/fetus?	21 (100%)	30 (93.8%)	36 (92.3%)
Can X-ray make you feel nauseous / vomit?	7 (17.9%)	9 (28.1%)	35 (32.1%)
Can CT-scan make you feel nauseous / vomit?	28 (71.8%)	22 (68.8%)	51 (45.9%)
Can MRI make you feel nauseous / vomit?	18 (47.4%)	16 (50%)	56 (50.9%)
Can US make you feel nauseous / vomit?	34 (87.2%)	29 (90.6%)	104 (93.7%)
Can X-ray damage your immune system?	20 (51.3%)	15 (46.9%)	72 (65.5%)
Can CT-scan damage your immune system?	29 (74.4%)	23 (71.9%)	70 (63.6%)
Can MRI damage your immune system?	25 (64.1%)	27 (84.4%)	63 (57.8%)
Can US damage your immune system?	37 (94.9%)	30 (93.8%)	95 (85.6%)
Does X-ray increase the risk of having cancer?	28 (73.7%)	24 (75%)	87 (78.4%)
Does CT-scan increase the risk of having cancer?	36 (92.3%)	29 (90.6%)	73 (65.8%)
Does MRI increase the risk of having cancer?	31 (79.5%)	29 (90.6%)	60 (55%)
Does US increase the risk of having cancer?	39 (100%)	31 (96.9%)	94 (84.7%)
Can X-ray damage your skin (make inflammation, destruction of skin and nails)?	20 (51.3%)	11 (34.4%)	43 (39.1%)
Can CT-scan damage your skin (make inflammation, destruction of skin and nails)?	27 (69.2%)	18 (56.3%)	45 (40.5%)
Can MRI damage your skin (make inflammation, destruction of skin and nails)?	8 (20.5%)	6 (18.8%)	36 (32.4%)
Can US damage your skin (make inflammation, destruction of skin and nails)?	36 (94.7%)	28 (87.5%)	102 (91.9%)
Does the likelihood of getting adverse effects after X-ray depend on the frequency of the test done (times/ a year)?	31 (79.5%)	30 (93.8%)	88 (79.3%)
Does the likelihood of getting adverse effects after CT-scan depend on the frequency of the test done (times/ a year)?	33 (84.6%)	30 (93.8%)	87 (78.4%)
Does the likelihood of getting adverse effects after MRI depend on the frequency of the test done (times/ a year)?	10 (47.6%)	17 (53.1%)	9 (23.1%)
Does the likelihood of getting adverse effects after US depend on the frequency of the test done (times/ a year)?	16 (76.2%)	22 (68.8%)	22 (56.4%)

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