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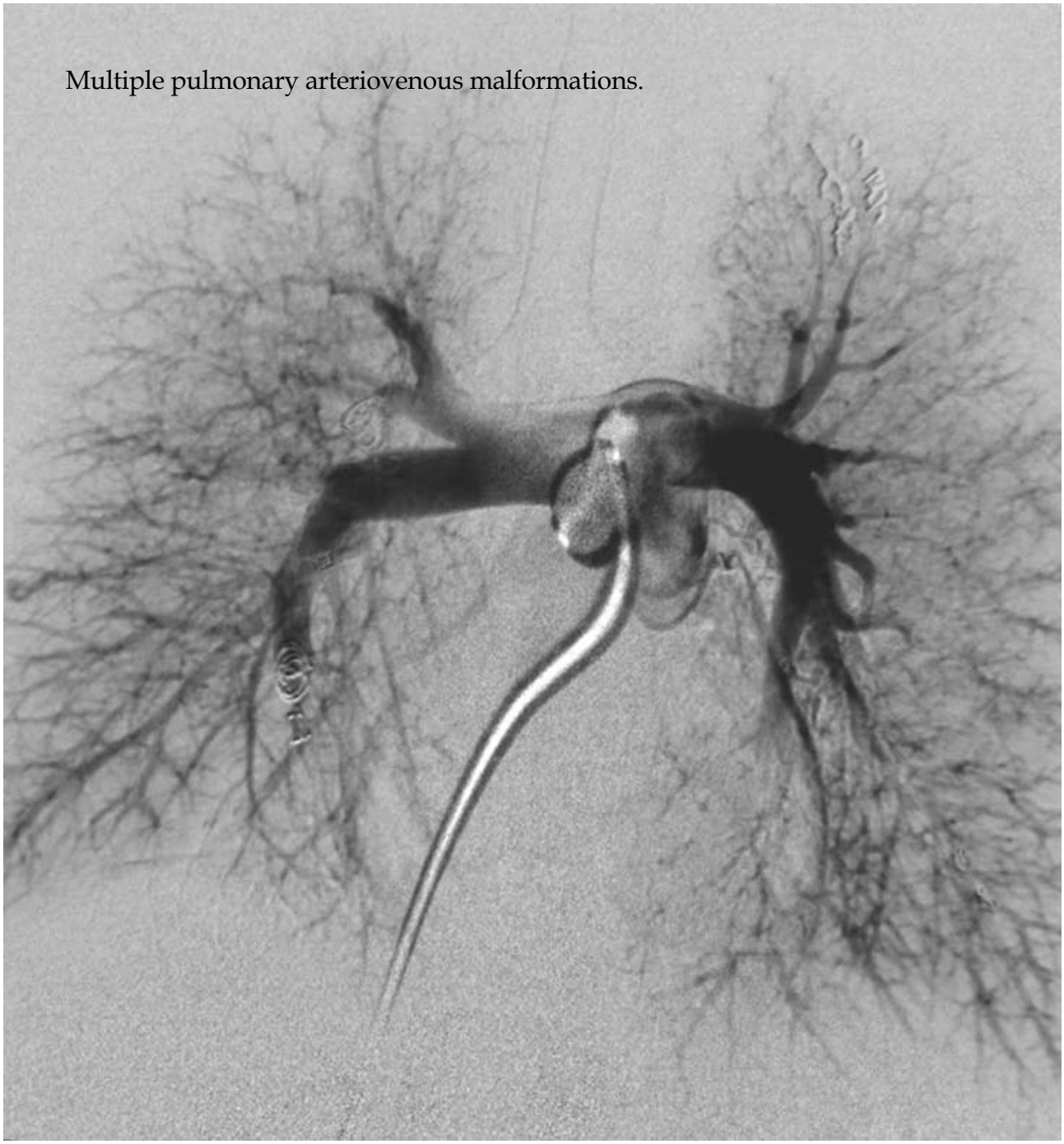

Multiple pulmonary arteriovenous malformations.

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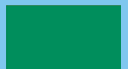

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EDITORIAL

Interventional treatment of pulmonary arteriovenous malformations

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Abstract

Pulmonary arteriovenous malformations (PAVM) are congenital vascular communications in the lungs. They act as right to left shunts so that the blood running through these malformations is not oxygenated or filtered. These patients are typically hypoxaemic with exercise intolerance and are at high risk of paradoxical emboli to the brain and other organs. These malformations are most commonly seen in hereditary haemorrhagic telangiectasia (HHT) (Mb. Osler-Weber-Rendu syndrome). Nowadays, the generally accepted treatment strategy of first choice is embolization of the afferent arteries to the arteriovenous malformations. It is a minimally invasive procedure and at the same time a lung preserving treatment with a very high technical success, high effectiveness and low morbidity and mortality. Embolization prevents cerebral stroke and abscess as well as pulmonary haemorrhage and further raises the functional level. Embolization is a well-established method of treating PAVM, with a significant effect on oxygenation of the blood. Screening for PAVM in patients at risk is recommended, especially in patients with HHT.

INTRODUCTION

Pulmonary arteriovenous malformations (PAVM) are congenital low pressure right-to-left shunts in the pulmonary vasculature bypassing the capillaries and thus causing decreased oxygenation of the arterial blood and reduced filtering of the blood. Most PAVM are high-flow shunts but a few are not and may consequently go undetected for a long period. Furthermore, PAVM patients can be asymptomatic because they have had their malformations for several years but will typically present with hypoxaemia and polycythaemia. Thus, they often have exercise intolerance, cyanosis and drumstick fingers. In addition, they have an increased risk of paradoxical emboli to the systemic circulation and subsequent infarctions and abscesses in the organs, especially the brain. Severe neurological events such as transitory cerebral ischaemia, stroke, and cerebral abscess occur in 30%-40% of patients with untreated PAVM[1-3] and 40%-50% of patients with PAVM have a history of migraine, headache or transient ischemic attacks[4]. Thus, there is an increased prevalence of neurologic symptoms among patients with hereditary haemorrhagic telangiectasia (HHT) (Mb. Osler-Weber-Rendu)[2]. There is also a risk of PAVM rupture, especially during

pregnancy, with resulting severe bleeding which may be lethal[2].

Therefore, there is evidence-based indication to treat these malformations[2].

In more than 75% of cases, PAVM appear in patients with HHT[5]. About 25%-30% of all patients with HHT have PAVM[1,4]. The prevalence of HHT is estimated to be 1 per 5000-10 000[6,7] and the prevalence of PAVM in the population is about 1 per 20 000. PAVM and shunts are rarely seen in relation to other diseases like hepatic cirrhosis, mitral valve stenosis, post trauma, actinomycosis, tuberculosis, and schistosomiasis[8].

HEREDITARY HAEMORRHAGIC TELANGIECTASIA

HHT is an autosomal dominant inherited vascular disease with high penetrans but variable symptomatology. Two subtypes have been defined with mutations in chromosome 9q34 in type 1 and mutations in chromosome 12q31 in type 2. Furthermore, the SMAD4 gene has been shown to be involved in a very rare HHT type combined with juvenile polyposis[9]. The manifestations of HHT are localized to the capillaries and are caused by a defect in normal growth and repair of endothelial cells[10]. Thus, there is a tendency for capillary vascular telangiectasias to form in the skin and mucosa membranes and arteriovenous malformations in the internal organs, most commonly the lungs, but almost all organs can be affected. Epistaxis is the most frequent symptom and is seen in about 95% of patients with HHT. PAVM is seen in about 45% of patients with HHT type 1, and in 12% of patients with HHT type 2[1,11]. Evidence-based international guidelines for the diagnosis and management of HHT have been published recently[12].

PULMONARY ARTERIOVENOUS MALFORMATIONS

Most patients with PAVM are discovered by screening patients with HHT[7]. PAVM are congenital but are usually not discovered until adult age because they grow with age. The morphology ranges from complex structures supplying and draining an aneurismal sac to small telangiectatic vessels. PAVM can be simple with only one afferent feeding segmental artery and draining vein (Figure 1) or complex with more than one supplying arteries to the PAVM (Figure 2A). Most PAVM are localized to the lower lobes but they can be seen all over the lungs (Figure 3A). It is generally accepted that there is indication for embolization when the feeding artery is 3 mm or more in diameter[2]. Patients with PAVM and without known HHT should be examined for HHT.

DIAGNOSIS

Most patients are found by screening of patients and their closest relatives with HHT[1,7], but some patients without HHT are occasionally found based on patient history (dyspnoea on exertion, cerebral insult/abscess, hemoptysis), clinical findings or pathological findings of rounded tumors on chest X-rays (Figure 4). Thus, some have been suspected of pulmonary malignancy in the initial phase. Lung biopsy should, however, be avoided as it might induce severe bleeding. Only about 66% of PAVM are visible on chest film depending on the size and location. Other patients will primarily be admitted to hospital because of neurological complications and with undiagnosed PAVM. Suspected patients will have a clinical examination, chest X-ray and contrast echocardiog-

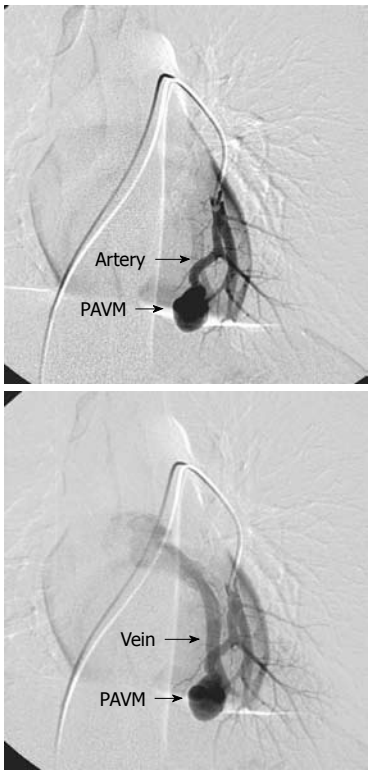

Figure 1 Simple pulmonary arteriovenous malformations with one afferent (feeding) artery and one efferent (draining) vein. PAVM: Pulmonary arteriovenous malformations.

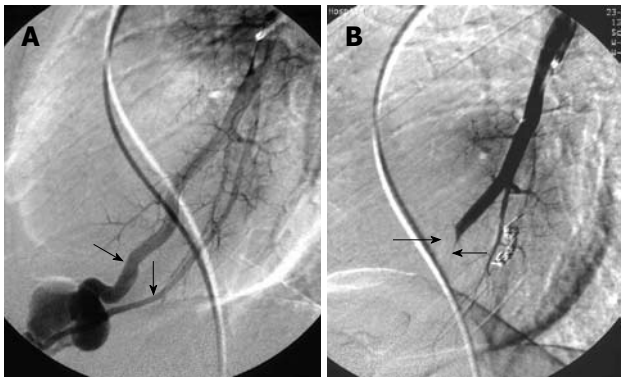

Figure 2 Complex pulmonary arteriovenous malformations. A: Two afferent (feeding) arteries (arrows); B: After embolization with balloon in one feeding artery (arrows) and coils in the other.

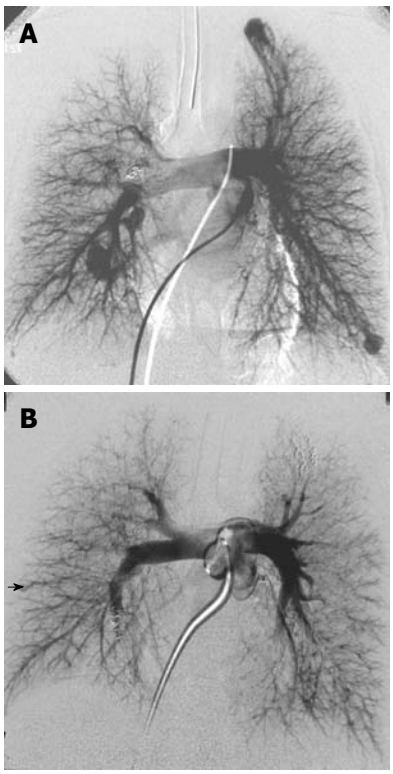

Figure 3 Multiple pulmonary arteriovenous malformations. A: In both lungs; B: Multiple pulmonary arteriovenous malformations (PAVM) after embolization. One small PAVM on the right side has been left untreated because of small sized feeding artery (arrow).

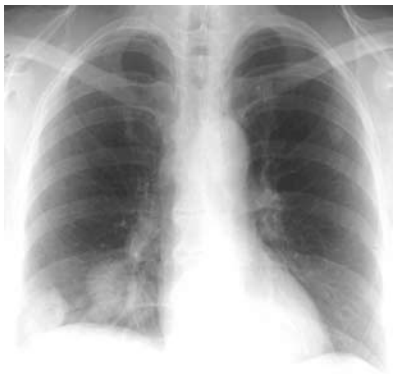

Figure 4 Pulmonary arteriovenous malformations in both lungs, visible on the chest X-ray.

raphy performed initially. If echo contrast bubbles after injection into a peripheral vein appear in left-sided heart chambers a couple of heart cycles after being visible in right-sided chambers, this is indicative of a right-to-left shunt in the lungs. If these examinations are suggestive of PAVM, further examinations will include multi-slice computed tomography (CT) without contrast media, arterial blood gas analysis (partial pressure of oxygen in arterial blood), and pulmonary angiography[13,14]. On multi-slice CT, the characteristic afferent and efferent vessels to the PAVM sac will often be visible (Figure 5)[15,16]. Finally, pulmonary angiography is performed with catheterization

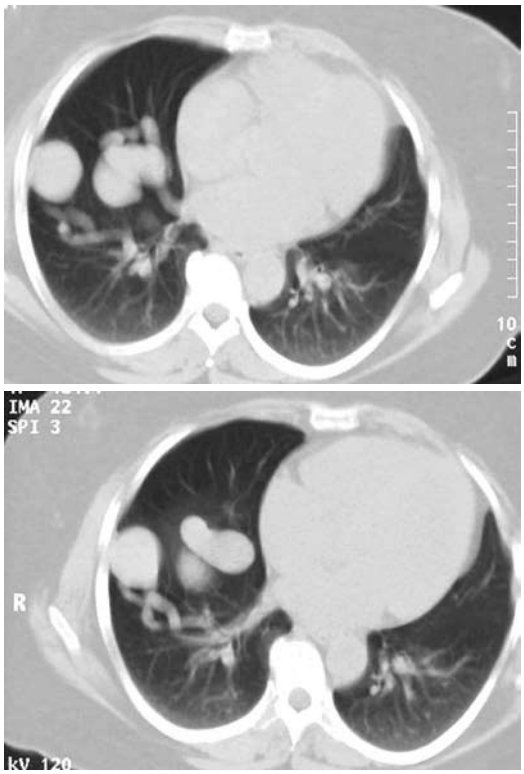

Figure 5 Computed tomography of the chest showing pulmonary arteriovenous malformations with afferent and efferent vessels.

through the femoral vein and selective contrast injection in both pulmonary arteries in at least two projections, and if needed additional projections in the anatomic position, that best profiles the artery and its entrance into the malformation.

All patients with HHT and their closest relatives, patients with hepatorenal syndrome, with unexplained dyspnoea on exertion, cerebral abscess or stroke should be screened for PAVM.

EMBOLIZATION METHODS

In 1977, percutaneous transluminal embolization of PAVM was introduced as a treatment option[17,18]. This treatment has since shown to be effective with a high success rate and few complications[2,3,19-22], and has therefore replaced surgery as the first-line treatment. The advantages of embolization are that the afferent feeding artery to the PAVM is occluded as close as possible to the PAVM sac and at the same time spares the adjacent normal pulmonary arteries (Figures 2, 3B, 6 and 7). Furthermore, selective, percutaneous, transluminal embolization is a minimally invasive procedure which is performed under local analgesia and without need of convalescence. Embolization is performed using transfemoral venous access to the pulmonary arteries. A 7F J-shaped guiding catheter with a 5F diagnostic vertebral J-shape or another appropriate shape according to the angulation of the target vessels inside is then inserted. A curved hydrophilic guidewire is used inside the catheters for crossing the right-sided heart chambers and for

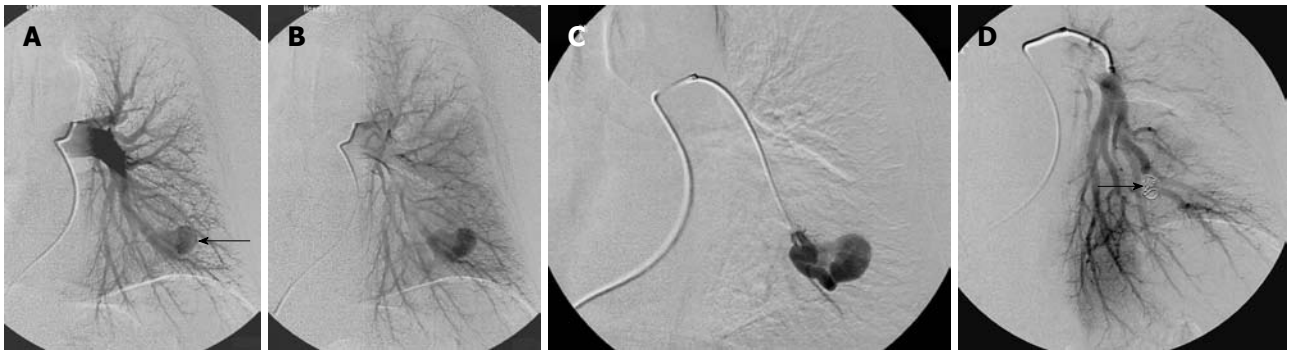

Figure 6 Simple pulmonary arteriovenous malformations. A, B: Before embolization; C: After selective catheterization of the feeding artery; D: After embolization with coils (arrow).

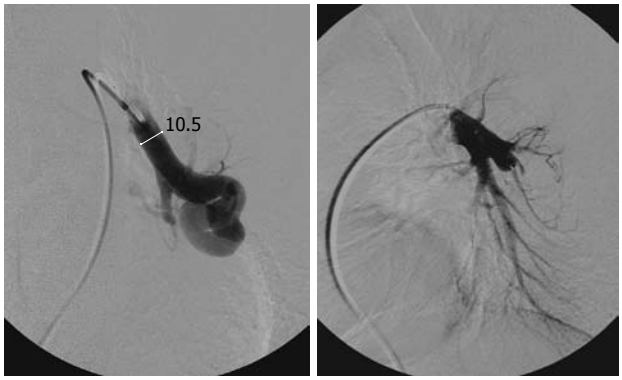

Figure 7 Embolization of simple pulmonary arteriovenous malformations with vascular plug.

selective catheterization of the pulmonary artery branches. Coils can be delivered through the diagnostic catheter and microcoils through a microcatheter inside the diagnostic catheter. Use of coaxial or triaxial catheters allow for precise placement of the coils. After embolization, the PAVM usually shrinks and leaves a fibrous scar. Transcatheter embolization is established as the preferred treatment for PAVM which have one (simple) (Figures 6 and 7) or more (complex) (Figure 2) feeding arteries of more than 3 mm or smaller if amenable to embolization[2]. Embolization is usually performed with coils, but years ago detachable silicone balloons were also used[13,14,23]. Pushable coils come in all sizes and a huge variety of shapes. They are easy to deliver through a diagnostic or microcatheter and are relatively cheap. Careful "packing" and cross-sectional occlusion by the coils is essential for embolization. It can be achieved using the "anchor" or "scaffold" technique[4] and may reduce the recanalization rate. Recanalization or primary insufficient embolization after use of coils has, however, been described in about 8%-15% of cases[19,20,24-26]. Detachable coils are even more precise and safe to deliver and can be retracted and replaced if necessary before final delivery, but they are more expensive and are usually not routinely used. Vascular plugs are increasingly used[27] (Figures 7 and 8). The vascular plug is a self-expandable, cylindrical nitinol wire-mesh occlusion device. A microscrew is welded to the plug and attached to a delivery wire.

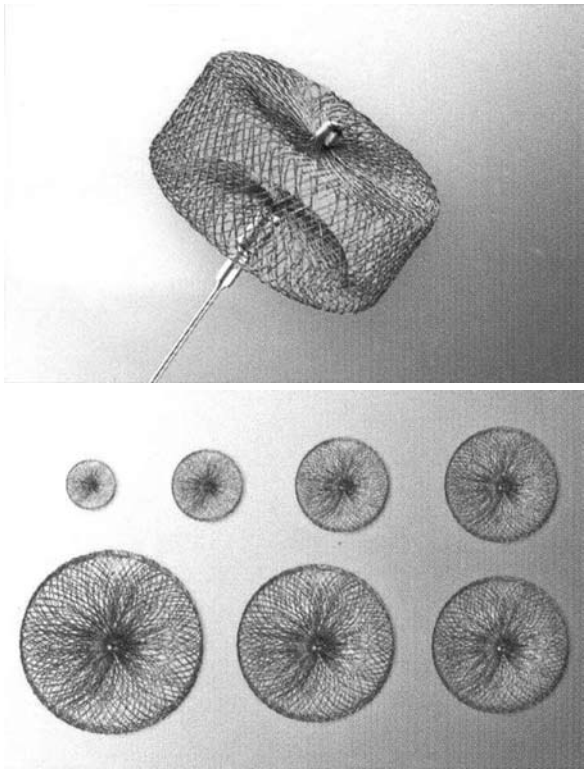

Figure 8 One version of a vascular plug.

They are available in diameters of 4-22 mm and the newest versions pass through 5-8F catheters or long sheaths. They are also detachable and can be retracted, removed, exchanged or repositioned very precisely and safely before final delivery by a precise, controlled detachment. In tortuous and small calibrated vessels, coils are preferred because they are more flexible during delivery through the catheter and available in small sizes. In most cases, multiple coils are necessary to achieve complete occlusion while one plug often will do the job, and it is more time consuming to deliver multiple coils than one plug. The potential for recanalization or incomplete occlusion by the plug is probably lower than that of the coils, especially if it is not possible to pack the coils properly. Personal experience with and preference for a certain device will often be decisive for the choice made.

EMBOLIZATION RESULTS

Technical success with occlusion of the feeding artery is achieved in about 95%-100% of cases in experienced hands[13,14,28]. A significant reduction of the pulmonary shunt after embolotherapy has been demonstrated by contrast echocardiography and by raised arterial blood partial pressure of oxygen[13,14,19]. Furthermore, the majority of patients experience a higher functional level and better performance after treatment[14,19]. Embolization is a safe treatment and complications and adverse effects during and after PAVM embolization are not severe. Side effects of this therapy are seen in about 10%-20% of cases[2,13]. Self-limited pleurisy with or without a small pulmonary infiltration and respiratory chest pain usually starting 2-4 d after treatment is seen in 10%-15%[2,14], precordial pain in 2%-5%, primary coil dislocation or malpositioning during delivery in 4%. Catheter-induced bradycardia and ectopic heart beats are common during catheterization but are self-limiting and will disappear after removal or replacement of the catheter from the heart. A transient rise in temperature for 1 or 2 d is common following embolization (post embolization syndrome). Secondary dislocation of coils after deployment and mortality have never been reported in relation to this treatment[2,20]. Clinical and anatomical evaluation after embolization of PAVM is important to detect persistent or reperfused lesions because of recanalization, presence of accessory feeding arteries, pulmonary collateral vessels, and bronchial collateral vessels and growth of non-embolized lesions. These patients will often have symptoms but a significant minority are asymptomatic[29].

CONCLUSION

Embolization of PAVM is a definitive treatment and is a well-established method with a significant effect on oxygenation of the blood and prophylactic effect on paradoxical emboli to the brain. It is a minimally invasive, safe and lung-preserving treatment with high effectiveness and low morbidity and mortality. Patients with HHT and their first degree relatives should be screened for PAVM.

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REVIEW

Imaging of benign and malignant cystic pancreatic lesions and a strategy for follow up

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Abstract

Cystic lesions in a variety of organs are being increasingly recognized as an incidental finding on cross-sectional imaging. These lesions can be benign, premalignant or malignant. When these cystic lesions are small it can be difficult to characterize them radiologically. However, with appropriate clinical history and knowledge of typical imaging features of cystic pancreatic lesions this can enable accurate diagnosis and thus guide appropriate treatment. In this review, we provide an overview of the most common types of cystic lesions and their appearance on computer tomography, magnetic resonance imaging and ultrasound. We will also discuss the follow up and management strategies of these cystic lesions.

Key words: Cystic pancreatic lesions; Follow up management; Imaging

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INTRODUCTION

Cystic lesions of the pancreas can be malignant or benign, occur in a wide range of sizes, and may or may not cause clinical symptoms. These lesions are often identified incidentally on cross-sectional imaging obtained for other reasons. The correct characterization of any cystic pancreatic lesion is critical in determining appropriate management.

Methods currently available for imaging cystic pancreatic lesions include contrast-enhanced computed tomography (CECT), ultrasound (US), endoscopic US (EUS), magnetic resonance imaging (MRI), and positron emission tomography (PET)/CT. However, the utility of PET/CT is still under investigation. EUS and transabdominal US have the disadvantage of being operator-dependent, but EUS is able to visualize cystic lesions in real time, and biopsy and cyst fluid analysis can be performed simultaneously. EUS is able to visualize cystic lesions in real time, and can guide biopsy; its primary limitations include its invasive nature, and the fact that results are operator-dependent. Transabdominal ultrasonography, is non-invasive, but offers limited resolution because of the depth of tissue penetration needed, and is therefore limited in patients with a large body habitus, and importantly the pancreas may be obscured by overlying bowel gas. Calcifications can be better seen on CECT; although septations may or may not be well seen. Septations are better seen on MRI and cyst contents can be identified due to better soft tissue contrast, however, detection of mucin is equivocal and spatial resolution is lower than that of CT. In this

article we will discuss commonly seen pancreatic cystic lesions and their appearance on imaging.

CLASSIFICATION OF PANCREATIC CYSTIC LESIONS

Pancreatic cystic lesions can be divided into primary and secondary cystic lesions. Primary cystic lesions include pseudocysts, serous cystadenomas (SCAs), various mucin-containing cysts such as mucinous non-neoplastic cysts, mucinous cystadenomas, mucinous cystadenocarcinomas, intraductal papillary mucinous neoplasms, pseudopapillary tumors of the pancreas and lymphoepithelial cysts. Secondary cystic lesions are solid neoplasms that have undergone cystic changes such as primary ductal adenocarcinoma, and neuroendocrine tumors. In this article we will discuss primary cystic lesions. Secondary cystic lesions and metastatic lesions, such as renal cell carcinoma, that show cystic changes will not be covered.

In the past, the majority of pancreatic cystic lesions were thought to be pseudocysts, however, this is being re-revaluated given the use of thin section imaging. Hydatid cysts of the pancreas are rare, but should be considered in countries where this disease is endemic[1]. Primary pancreatic cystic tumors fall into one of three major groups; serous tumors, mucinous tumors and solid pseudopapillary tumors (SPT).

Most cystic pancreatic tumors that are incidentally diagnosed are asymptomatic and small[2]. As these cystic lesions grow larger they cause symptoms due to mass effect and the symptoms are vague and poorly localized. For example, intraductal papillary mucinous neoplasms (IPMNs) may cause epigastric pain which may mimic chronic pancreatitis[3].

Pancreatic pseudocysts

Pseudocysts have been reported to comprise 70% of all cystic lesions[4], however, that is being challenged because of the numerous instances of small cystic lesions being seen on cross-sectional imaging in patients without a history of pancreatitis. Pseudocysts occur following an episode of pancreatitis due to leakage of pancreatic enzymes, causing fat necrosis and hemorrhage. Pseudocysts are more often seen in alcoholics and can be associated with abdominal trauma. Hemorrhagic components may be seen in pseudocysts, and may be associated with intermittent or massive GI bleeding, which in turn is associated with increased mortality[5]. These fluid collections lack an epithelial lining and have a fibrotic wall[6]. While pseudocysts do not have a malignant potential, they may mimic malignant neoplasms such as mucinous neoplasms.

On imaging, pseudocysts typically are most commonly unilocular, without internal septations or mural nodules. Pseudocysts typically communicate with the pancreatic duct[4] but this is often not identifiable on cross-sectional imaging. On CECT (Figure 1), pseudocysts look like fluid collections and usually have an imperceptible or minimally visible wall, but the appearance can be variable[7]. On US, pseudocysts are usually hypoechoic with increased through transmission and may have internal debris. Cystic lesions with the characteristic appearance of pseudocysts, and a clinical history of recent pancreatitis, can typically be followed. Pseudocysts usually resolve over time, whereas neoplasms will persist or show interval growth. Importantly, for a pseudocyst to be considered a diagnostic possibility, a history of pancreatitis should be present; if such as history is absent, strong consideration should be given to the workup of such lesions as possible neoplasms.

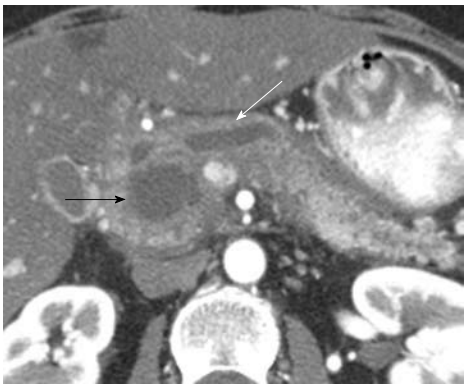

Figure 1 A 49-year-old woman with a history of epigastric and lower abdominal pain accompanied by abnormal liver function studies. Axial contrast-enhanced computed tomography scan of the abdomen shows cystic change (black arrow) within the pancreas with associated biliary ductal dilation (white arrow). When correlated with the patient's history and endoscopic ultrasound with FNA findings, this was consistent with a pseudocyst.

A complication that can be seen with pseudocysts is that of pseudoaneurysms, which occur when pancreatic enzymes erode adjacent vessels. Pseudoaneurysms are at risk of rupture and hemorrhage. The splenic, gastroduodenal and superior pancreaticoduodenal arteries are at greatest risk of pseudoaneurysm formation[8] in the setting of pancreatitis.

Simple cysts

True cystic lesions (Figure 2) of the pancreas[9,10], which are lined by epithelium, are seen in patients with von Hippel Lindau disease, cystic fibrosis or polycystic kidney disease[11] and have an imaging appearance similar to that of simple cysts seen in the liver and kidneys[10]. On CECT, simple cysts have a thin wall and have a Hounsfield value equal to that of fluid. On US they are anechoic with posterior acoustic enhancement and on color Doppler evaluation they do not show vascularity.

Mucinous cystic neoplasms

Mucinous cystic neoplasms (MCNs) are usually solitary, range from 6-35 cm in size, are generally found in the body and tail of the pancreas and account for 10% of cystic neoplasms seen in the pancreas[12]. These tumors typically have a thick wall and are multilocular[3]. They do not communicate with the main pancreatic duct except through fistulae[3,13]. MCNs have < 6 locules which are usually >

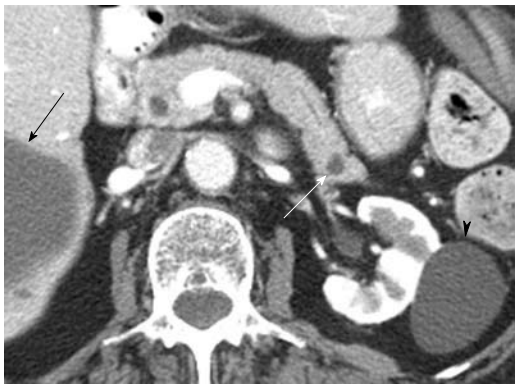

Figure 2 An 80-year-old woman with a history of hypertension, congestive heart failure and colon cancer. Axial contrast-enhanced computed tomography of the abdomen shows a small low attenuation lesion in the pancreatic tail consistent with a cyst (white arrow), a cyst within the kidney (arrowhead) and a cyst within the liver (black arrow).

2 cm in size. The internal contents of the cyst may be hemorrhagic, necrotic or consist of mucinous material. MCNs typically have internal nodules, which histological may harbor high-grade dysplasia or invasive carcinoma[13]. MCNs of the pancreas resemble MCNs of the ovary and are seen in women of reproductive age (> 95%) (mean age, 45 years)[13-16]. The cyst wall has two layers. The inner layer of cells secretes mucin and the outer layer of cells resembles ovarian stroma. Calcifications may be noted in the periphery of the tumor or in the capsule in 10%-25% of cases[7]. These patients may present with vague abdominal pain, weight loss and anorexia.

MCNs can appear on imaging as a single large cyst with multiple locules, a thick outer wall, septations, and enhancing intramural nodules. Sometimes calcifications can be present on the outer wall[3], and the wall may enhance on the delayed phase. On MRI, the fluid within the cyst may have a low signal on T1-weighted images (T1WI) and a high signal on T2WI, however, increased signal on T1WI has also been observed[17]. It is not possible on imaging to exclude malignancy but the presence of enhancing nodules increases the likelihood[16].

Mucinous cystadenocarcinomas

Mucinous cystadenocarcinomas (Figure 3) are part of a continuum of mucinous cystadenomas. Importantly, it is not possible to differentiate benign mucinous cystadenomas from malignant mucinous cystadenocarcinomas. Nevertheless, a variety of signs, including intracystic nodules, irregular wall thickening, or size > 3-4 cm all increase concern for malignant mucinous cystadenocarcinoma[14].

Intraductal papillary mucinous neoplasms

Ohashi *et al*[18] first described IPMNs in 1982[19]. These tumors are more commonly seen in males, with presentation typically in the seventh to ninth decade of life. Patients may present with epigastric abdominal pain, which is frequently exacerbated by food[3]. The presentation of pain can resemble that of pancreatitis and is due to blockage of the pancreatic ducts by mucin in the main

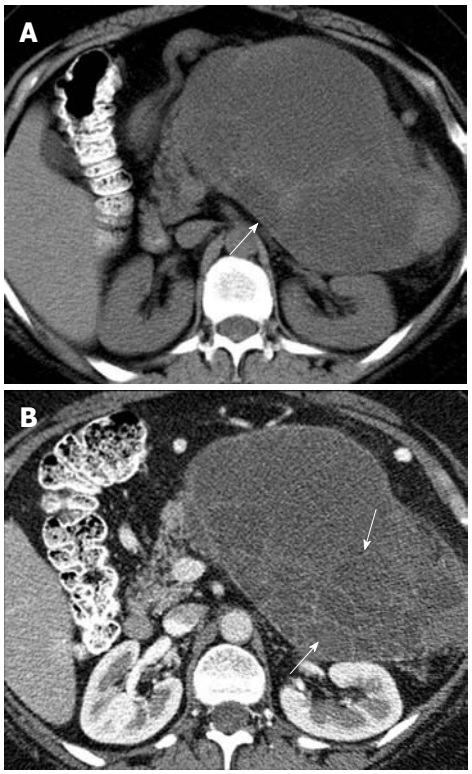

Figure 3 A 48-year-old woman with left upper quadrant pain. A: Axial non-contrast computed tomography (CT) scan of the abdomen shows a heterogeneous mass (arrow) in the left upper quadrant; B: Axial contrast-enhanced CT of the abdomen shows enhancing septa (arrows) within the mass.

duct form of this disease. Other symptoms and signs include weight loss, fever and jaundice[20].

IPMNs are characterized by whether they involve the main pancreatic duct or side branches[12]. Prognosis depends on the location of the tumor[21]. Only 5%-10% of the time do these involve the entire pancreas; such tumors are usually multifocal[22]. There are three main types of IPMNs: the main duct type, side branch duct type and combined/mixed[23]. The mucin produced by these tumors accumulates within ducts causing cystic dilation of the ducts. Histologically tumors may range from hyperplasia to invasive carcinoma[24]. The risk of malignancy in IPMNs increases with increasing caliber of the main pancreatic duct, visualization of mucin at the ampulla of Vater, and the clinical presence of jaundice and/or diabetes[25-27].

Main duct type IPMN

The main duct type of IPMN arises from the epithelium of the main pancreatic duct. IPMN is classified by the World Health Organization (WHO) based on the degree of epithelial dysplasia: adenoma, borderline tumor, and carcinoma (either *in situ* or invasive)[28]. Histologically they differ from mucinous cystic tumors in that they lack ovarian-type stroma. IPMNs are more commonly seen in men with a mean age at presentation of 65 years[13]. The pathognomic feature of a main duct IPMN is visible mucin extruding from the ampulla of Vater on endoscopic retrograde cholangiopancreatography[13]. The tumors may

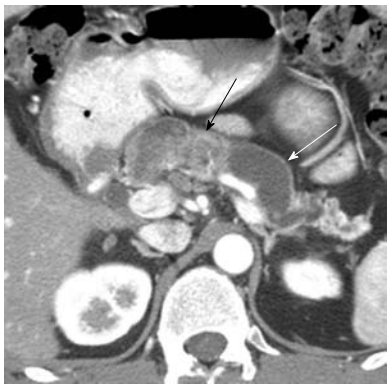

Figure 4 A 48-year-old man presenting with pancreatitis and exocrine pancreatic insufficiency and a mass in the pancreas representing diffuse intraductal papillary mucinous neoplasm of the pancreas. Axial contrast-enhanced computed tomography of the abdomen shows dilated main pancreatic duct (white arrow) due to mucin production and an enhancing mass in the main pancreatic duct (black arrow) representing a main duct intraductal papillary mucinous neoplasm.

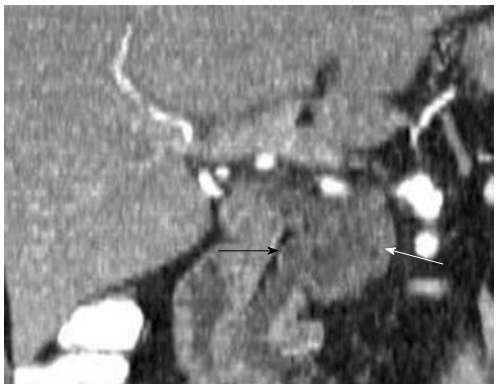

Figure 5 A 57-year-old man with cysts in the pancreas. Coronal reformatted contrast-enhanced computed tomography scan of the abdomen shows a cystic lesion in the pancreas (white arrow) which communicates with the main pancreatic duct (black arrow).

be papillary or polypoid in appearance, and arise from pancreatic ductal epithelium which are transformed to mucinous cells[12,29]. The tumor nodule may show cell atypia, ranging from slight dysplasia to frank invasive carcinoma with the likelihood of invasive cancer increasing significantly when the size of the main duct increases to 1 cm or more in diameter. The time to progress from benign to malignant disease is thought to range from 5 to 7 years[12,30]. Approximately 60%-92% of cases demonstrate invasive carcinoma[29,31] on histologic examination.

The appearance of main duct IPMN on CT (Figure 4) depends on its location. The entire main pancreatic duct is dilated if the tumor is present in the head of the pancreas and segmental dilation of the duct can be seen if the tumor is present in the body. However, as disease progresses the entire duct often becomes dilated[13,32]. Pancreatic atrophy is often present secondary to duct obstruction and often consequent episodes of pancreatitis occur. These recurrent episodes of pancreatitis will often cause a loss of the bright T1 signal of the pancreas on non-contrast images and delayed uptake of contrast best seen on delayed images, thought to indicate the presence of fibrosis[33], ultimately resulting in glandular atrophy and dysmorphic calcifications. In the setting of main duct IPMN, the features of particular concern for malignancy or invasive carcinoma include main duct dilation > 1.5 cm in diameter, enhancing nodules, diffuse or multifocal involvement of the pancreatic duct, presence of a soft tissue mass, or bile duct obstruction. Main duct IPMNs even without the above-mentioned features are considered premalignant and are usually resected[9,10].

Branch duct IPMNs

Branch-type IPMNs are usually indolent and are found in younger patients compared to main duct IPMNs. They are considered to have a lower malignant potential than main duct forms of IPMN but can evolve to invasive tumors; therefore, close attention to size (less than or greater than 30 mm) and imaging characteristics (wall thickening, internal nodules) is important as these are predictive of invasive tumor[34]. The prevalence of cancer in branch duct forms of IPMNs has been reported to be 6%-46%[9,28,35]. Tumors > 30 mm are at higher risk for invasive cancer compared to simple appearing cystic side branch lesions < 30 mm where the likelihood of invasive cancer is much lower[35,36]. On cross-sectional imaging, thin section CECT (Figure 5) or heavily T2 weighted MRI such as MRCP, communication of the cystic side branch IPMN may be identified with pancreatic ducts and is a useful diagnostic sign[37]. Side branch IPMNs may be unilocular or have the appearance of "a bunch of grapes." Mucin is secreted by this tumor can extrude into the pancreatic ducts. These tumors can be multifocal, as all pancreatic ductal epithelium may be at risk for developing malignancy[35]. These tumors may mimic a SCA; however, the communication with the main pancreatic duct helps differentiate between the two entities. The ductal communication is reportedly better seen on T2WI MRI sequences than CECT[23,38].

Combined IPMN

In a combined IPMN, the main pancreatic duct and the side branches are dilated. The main duct dilation of > 15 mm is a predictor of malignancy, whereas ductal dilation of 11 mm may be seen in benign or borderline IPMNs[30]. The presence of nodules within the duct or enhancement of the main pancreatic duct walls are some of the signs which suggest malignant mixed-type IPMNs and are similar to the features seen in the main duct IPMN[30].

Imaging follow-up of IPMN

CECT and/or MRI can be used to follow up IPMNs. PET/CT is an evolving modality for detecting malignancy in cystic pancreatic lesions. In a study of 17 malignant cystic lesions by Sperti *et al*[39], the sensitivity, specificity, positive and negative predictive value, and accuracy of 18-FDG PET and CT in detecting malignant tumors were 94%, 94%, 89%, 97%, and 94% and 65%, 88%, 73%, 83%, and 80%, respectively, however, these patients already had findings suspicious for malignancy based on

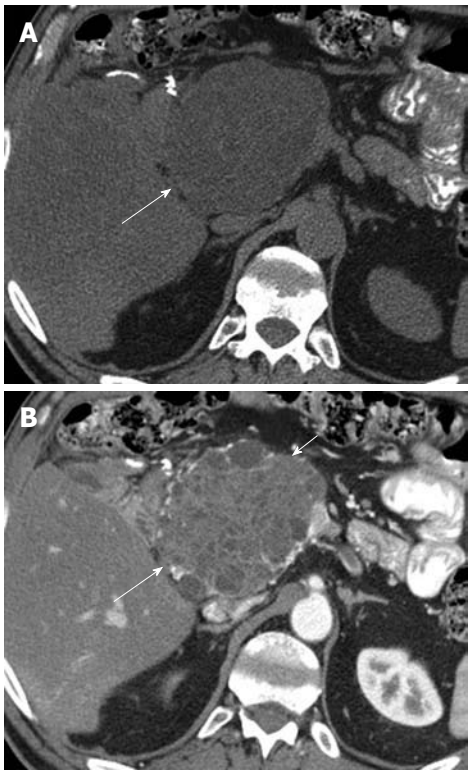

Figure 6 A 62-year-old man with history of epigastric discomfort. A: Axial non-contrast computed tomography (CT) of the abdomen shows a mass in the pancreatic head (long arrow); B: Axial contrast-enhanced CT of the abdomen shows enhancement within the mass (long arrow) and cystic components (short arrow) suggestive of a microcystic serous cystadenoma.

CECT findings alone. According to international guidelines developed during the Eleventh Congress of the International Association of Pancreatology held in Sendai, Japan, from July 11 through 14, 2004, the small, simple appearing IPMNs and mucinous cystic lesions can be followed by imaging if the cystic lesion is simple (i.e. no internal nodularity, no wall thickening) and < 1 cm, at an interval of 6-12 mo if 1-2 cm, and every 6 mo if 2-3 cm[9]. Findings suggestive of invasive features such as internal nodularity, wall thickening, changes in adjacent pancreatic parenchyma, *etc.* would be indications for biopsy and/or potential resection. Depending on the patient's age, MRI can be considered for follow-up to reduce radiation exposure. Given the risk of malignancy throughout the pancreas, patients who have undergone resection of an IPMN, even if benign on pathology, should have surveillance of the remaining pancreas[9].

Serous cystadenomas

SCAs account for up to 30% of pancreatic cystic neoplasms. They can arise from any part of the pancreas but are commonly seen in the body and tail. SCAs are more commonly seen in women, in their sixth decade of life[13,40] and may produce non-specific symptoms, such as epigastric abdominal pain, and weight loss, if they are large. They are classified into two categories: microcystic SCAs (mutilocular) and oligocystic lesions (unilocular). SCAs are usually < 5 cm in diameter, with a median size of 25-30 mm. These tumors have a well-defined lobulated contour. On cytology they have clear or eosinophil rich cytoplasm. These tumors can be associated with von Hippel-Lindau (VHL) disease[32,41], which is a syndrome consisting of hemangioblastomas of the retina and central nervous system and pheochromocytomas. The VHL gene can also be seen in sporadic cases of SCA. Even though SCAs are predominantly benign, a meta analysis of 673 lesions was found to suggest that the risk of, malignancy in these tumors is approximately < 3%, and this may be an overestimate as all incidentally found SCAs have not been reported in the literature[32,42-44].

Microcystic SCAs

Microcystic SCAs, also known as glycogen rich adenomas, are multilocular. Usually the number of locules is > 6 and the size of these locules ranges from 0.1 to 2.0 cm and they may have a calcified stellate scar[32,45]. These are cystic masses and on non-contrast CT examination (Figure 6), their attenuation is < 20 HU, but they do enhance due to the presence of fibrovascular septa[32,45]. They are best described as having a "honeycomb" appearance. Since these tumors enhance they can easily be mistaken for solid masses if the cystic locules are very small or are very poorly visualized, therefore mimicking lesions such as neuroendocrine neoplasms on cross-sectional imaging.

In such circumstances, MRI may be helpful in demonstrating tiny cystic locules as these usually have a characteristic high T2 signal. These tumors do not communicate with the main pancreatic duct[46]. Prominent calcifications, if present, are readily identifiable on CT, but may show a signal void on MR images. A central scar with calcification, while highly suggestive of a SCA is seen in only 10%-30% of cases. On sonographic evaluation these tumors typically have the appearance of solid echogenic masses due to the many interfaces produced by the numerous cysts.

Oligocystic SCA

Oligocystic SCAs (Figure 7) are rare tumors and may be unilocular or multilocular but have much fewer and larger locules compared to the more common microcystic form of SCA. The individual cysts may be > 2 cm and only one locule is seldom seen. These lesions therefore can mimic MCNs on imaging[3,47] or even pseudocysts.

SCAs both oligocystic and microcystic can cause symptoms requiring resection. The growth rate of these tumors depends on their size seen at initial diagnosis. Tumors < 4 cm grow at a rate of 0.6 cm/year and tumors > 4 cm grow 0.12 cm/year[47,48], suggesting that resection is appropriate for large lesions, as larger lesions are more likely to be symptomatic[47,48].

Solid pseudopapillary tumors

SPTs were previously known by several other names including solid and cystic papillary epithelial neoplasms of the pancreas, papillary cystic neoplasms, Hamoudi tumors, or Frantz tumors. In 1996 they were renamed SPTs of the pancreas by the WHO[49]. SPTs are less common than

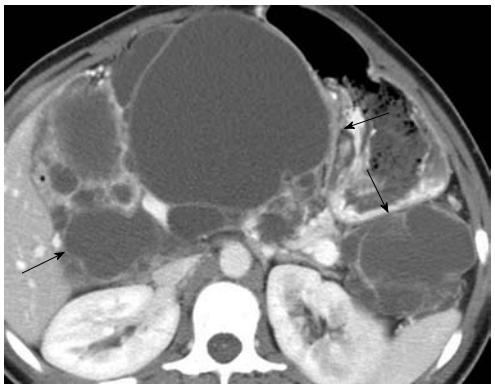

Figure 7 A 26-year-old woman with a history of von Hippel-Lindau syndrome. Axial contrast-enhanced computed tomography scan shows cystic lesions in the pancreas (black arrows) representing oligocystic serous cyst adenomas.

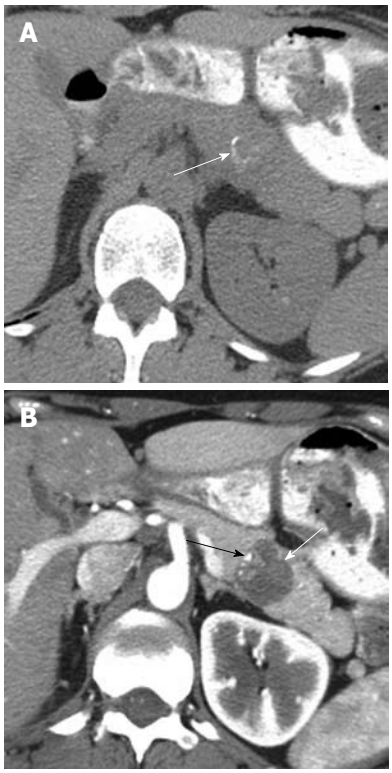

Figure 8 A 30-year-old woman with increasing abdominal discomfort and bloating. A: Axial non contrast computed tomography (CT) of the abdomen shows a solid mass in the pancreatic tail containing curvilinear calcification (arrow); B: Axial contrast-enhanced CT of the abdomen shows a hypoattenuating mass (white arrow) in the pancreas containing eccentric calcifications (black arrow) consistent with a solid papillary epithelial neoplasm.

IPMNs, SCAs and MCNs. They are usually seen in the second or third decade of life and occur more commonly in women than in men[50,51]. SPTs can have both neuroendocrine and epithelial components. They occur entirely in the pancreas, have no corollary in other organ systems and are reportedly of low malignant potential[52]. When these solid tumors undergo degeneration they develop cystic spaces[52]. Histologically, blood, necrotic debris, and foamy macrophages are found in the cystic areas[7,32]. These tumors commonly measure > 10 cm at presentation, can occur anywhere within the pancreas and can have eccentric calcification[53]. On cross-sectional imaging (Figure 8) these tumors are solid except for cystic components due to tumor degeneration. These tumors are well circumscribed, and on T2WI have slightly high signal intensity, although tumors which are predominantly cystic will have a high T2 signal intensity, which follows a fluid signal. These tumors can show a blood fluid levels. Blood in the cystic spaces can have a high signal on non-contrast T1 weighted images. These tumors can be differentiated from neuroendocrine tumors as they enhance progressively, whereas the latter shows arterial phase enhancement although the appearance of both tumor types is variable and considerable overlap can occur. Features suggestive of a benign histology include being well-encapsulated, smoothly lobulated, and the presence of rim calcifications[53]. Features raising concern for malignancy include disruption of the capsule and an eccentric lobulated margin with focal nodular calcification or amorphous/scattered calcifications[53]. Nodal metastases are rare, however peritoneal, cutaneous and hepatic metastases can occur following excision of SPT[52].

Considerations for imaging surveillance

The natural history of cystic pancreatic lesions is still unknown and selective observation is emerging[9,10,54,55]. CT and MRI are currently being used in assessment of pancreatic cystic lesions. CT is probably more widely used as it requires less scan time, offers higher spatial resolution, and is frequently the most accessible. While typically requiring a longer imaging time, MRI with MRCP can identify communication of the cystic lesion with the main pancreatic duct, however with currently available thin section imaging, CT can perform in a similar manner[45]. CT alone has an average accuracy of 61% in differentiating benign (43%) or potentially malignant (57%, papillary mucinous neoplasms, mucinous cystic neoplasms, cancer)[56]. The accuracy of MDCT is better than MRI in classifying cysts as mucinous or non mucinous at 71%-84.2% *vs* 39.5%-44.7%, respectively, whereas the accuracy of the two techniques in characterizing cysts into nonaggressive and aggressive categories is relatively similar (MDCT *vs* MRI, 75%-78% *vs* 78%-86%) respectively[57]. MRI has the additional advantage of higher inherent soft tissue contrast, and it does not utilize ionizing radiation, however in a recent study even though the sensitivity of MRCP for detection of morphologic characteristic was slightly better than that of MDCT, but the difference was not statistically significant[57]. FDG-PET/CT has been used to differentiate malignant from a benign cystic lesions depending on its metabolic activity but is still under investigation[39]. The reported negative predictive value, of 18-FDG PET in detecting malignant cystic tumors is 97%[39]. The high negative predictive value suggests that, when cystic lesion and is not metabolically active it is benign.

Indeterminate cysts should be followed as enlarging cysts have a higher probability for malignancy, with risk also increasing with increasing age (> 70 years)[58,59]. Cysts

3 cm or greater, even without the presence of a solid component, can have *in situ* cancer or invasive malignancy in up to 3% of cases[2,54,60,61]. If a cyst is not characterized on cross-sectional imaging sufficiently, then evaluation under EUS should be considered, with biopsy of nodules, if present, and aspiration of cyst contents, to test for such factors as mucin, amylase and tumor marker levels including CEA, can be obtained to differentiate mucinous (and therefore potentially malignant) from non mucinous lesions, regardless of lesion size.

Because of the risk of malignancy in mucinous cystic lesions or indeterminate cysts a more conservative approach is necessary[9]. Since asymptomatic cystic lesions < 3 cm in size, without wall thickening, without main duct dilation (≤ 6 mm), or mural nodules have a low risk of malignancy, these patients can be managed conservatively by follow-up with imaging. One algorithm suggested in the literature for lesions meeting the criteria described, is yearly follow-up if a lesion is < 10 mm, 6-12 mo follow-up for lesions between 10 and 20 mm, and for lesions > 2 cm 6-mo follow-up[9].

Surgical resection has been suggested for cases where the main pancreatic duct is > 6 mm in diameter, lesion size is > 30 mm, or intramural nodules are seen, given that the patient is a good candidate with reasonable life expectancy[9,10,61]. Alternatively, biopsy can be obtained under EUS to assess whether a lesion is mucinous or not. Mucinous lesions with such features typically proceed to biopsy.

Following surgery of a histopathologically confirmed benign IPMN, it has been suggested that patients should be followed yearly with either CT or MRI for the first 5 years and thereafter imaged if symptomatic[9]. It has also been suggested that in patients in whom invasive carcinoma is identified that they be imaged every 6 mo for the first 2 years, and to have yearly follow-up thereafter[35], as patients with invasive carcinoma can recur locally or develop distant metastases to the liver and/or lung[9,35]. It is notable that there are no clear guidelines regarding the length of follow-up in any of these groups of patients.

CONCLUSION

When a cystic lesion of the pancreas is discovered incidentally on routine cross-sectional imaging, it is important to correlate this with clinical history to accurately characterize the lesion. For example, a prior history of acute pancreatitis would likely suggest a pseudocyst. When a cystic lesion communicates with pancreatic ducts this may suggest IPMN. If such a lesion is associated with dilatation of the main pancreatic duct, or there is primarily dilatation of the main pancreatic duct, then a main duct type of mixed form of IPMN is a consideration. In menstruating females, a solitary, multilocular mass should raise concern for a mucinous cystadenoma/cystadenocarcinoma. In contrast, a cystic lesion in an elderly female with a honeycomb appearance, particularly if it contains a central scar that may be calcified, is indicative of a SCA. However, while characteristically benign, patients with SCAs > 4 cm have a risk of involvement of invasive structures and may be considered candidates for surgical resection.

Finally, there is a growing consensus that asymptomatic small (< 3 cm), simple appearing cystic lesions (no wall thickening, no internal nodules, no invasive features, no evidence of main duct dilation, *etc.*) can probably be followed because of the low risk of invasive malignancy. In contrast, if suspicious features are present, a more aggressive approach, including cyst aspiration, biopsy of solid components and potential surgical resection need to be considered. In conclusion, the radiologist plays an important role in the identification, characterization, monitoring and triaging of cystic lesions of the pancreas for appropriate treatment planning.

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REVIEW

Hyperdense artery sign on computed tomography in acute ischemic stroke

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Abstract

Despite the advent and growing availability of magnetic resonance imaging, the imaging modality of choice in the acute care of stroke patients in many institutions remains computed tomography. The hyperdense artery sign is the earliest marker of acute ischemic stroke. In this short review, we discuss the pathology, incidence, clinical aspects, imaging findings, significance and future questions that need to be addressed concerning this important sign.

Key words: Computed tomography; Early ischemic signs; Hyperdense artery; Stroke

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INTRODUCTION

Computed tomography still remains the key imaging diagnostic tool in the work-up of patients with acute stroke. This is mainly due to its wide availability and quick and robust performance. The hyperdense artery sign (HAS) has long been known as an indicator of occluding clots in cases of acute ischemia on non-enhanced cranial computed tomography (NECCT). A hyperdense cerebral artery in the setting of acute ischemic stroke was first reported by Gács *et al*[1] in 1983. It is the earliest sign, and is visible long before parenchymal changes which are known as early ischemic signs. In principle, it becomes visible with the onset of occlusion in a cerebral vessel. The histopathological correlate for the HAS is a thrombus occluding the vessel[2]. When a thrombus is forming, the local hematocrit level rises due to extrusion of plasma leaving clotted cells and debris behind. Thus, the attenuation rises from less than 40 HU in flowing blood to approximately 80 HU. In contrast to atheromatous calcifications (see below) a hyperdensity caused by the HAS is reversible[3].

OTHER CAUSES

The HAS has always been described as having a high specificity (90%-100%). Nonetheless, other causes of HAS have been described. Due to the linear correlation between attenuation and hematocrit level it is easily understood that a high hematocrit level leads to hyperdense arteries[4,5]. Other than with the HAS not only one vessel is affected but all intracranial arteries and veins (Figure 1). Naturally, when contrast agent is injected, all intracranial vessels appear hyperdense on NECCT, either because a short time has elapsed after injection or because of increased retention, e.g. because of renal impairment. As

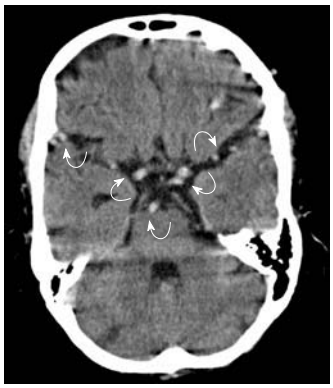

Figure 1 Non-enhanced cranial computed tomography of a 58-year-old female patient with a hematocrit of 58%. Note that all depicted intracranial arteries and veins appear hyperdense (curved arrows). No contrast agent was applied prior to the scan.

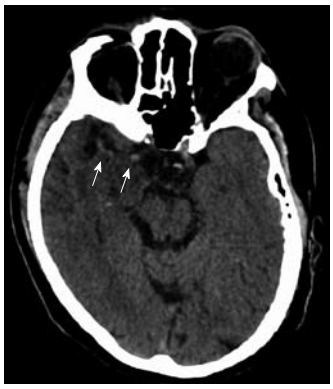

Figure 2 Pseudohyperdense right middle cerebral artery (arrows) due to underlying infection of the temporal lobe.

another possible cause for a HAS, Koo *et al*[6] described a hyperdense middle cerebral artery (MCA) due to viral infection. Of course, other objects such as plaque of atheromatous origin[7] or foreign bodies, e.g. catheter fragments can cause a hyperdense artery. There are reports of hyperdense arteries in the setting of dissection[8-12]. It is not clear whether the pathological correlate of the HAS in these cases is the intramural hematoma or the intraluminal thrombus. Hypodense brain parenchyma due to infection or tumors (Figure 2) surrounding the vessel can give the impression of a pseudohyperdense vessel[13]. Additionally, atheromatous vessel calcifications can raise vessel attenuation and it can be difficult to discriminate intraluminal from mural hyperdensities. To establish objective criteria for HAS, Koo *et al*[6] defined a ratio of 1.2 when compared to the non-affected contralateral vessel or an absolute value of > 43 HU.

LOCALIZATION

The HAS was first described in the MCA[1]. This is not surprising as the MCA is the most commonly affected vascular territory in strokes. Additionally, the MCA is the intracranial artery with the largest diameter which enables the detection of a hyperdensity in this vessel. Furthermore, almost its whole length runs within the imaging plane. There is an abundance of literature on the hyperdense MCA sign[14-25] (Figure 3). Other locations are less frequently reported. It has been described in the carotid artery (HICAS)[26], MCA distal branches as the "dot sign"[27,28], the anterior cerebral artery (HACAS)[29,30] (Figure 4), the posterior cerebral artery (HPCAS)[1,31,32] (Figure 5), the basilar artery (HBAS)[33-36] (Figure 6), and the vertebral artery[8].

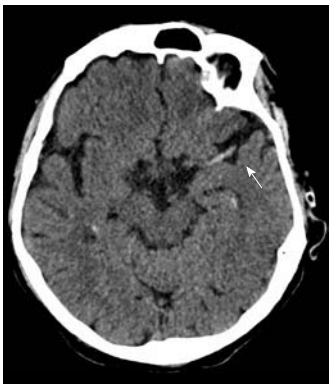

Figure 3 Hyperdense left middle cerebral artery sign (arrow) in a patient presenting with signs of left hemispheric stroke.

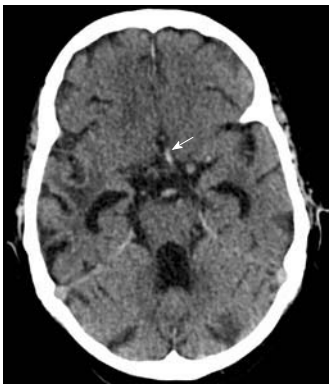

Figure 4 Hyperdense left anterior cerebral artery (arrow) in a patient who presented with right-sided hemiparesis.

The clinical presentation correlates with the localization of the HAS except for HBAS. Sudden onset of focal neurological symptoms (HICAS: hemispheric syndrome; HMCAS and "dot sign": brachio-facial dominant paresis, aphasia; HACAS: crural dominant paresis; HPCAS: visual field loss, hemiparesis) can guide the clinician to the affected artery.

In the case of an occluded basilar artery, the patient usually presents with loss of consciousness. The differential diagnosis include a variety of non-neurological causes and vary from heat exhaustion to intoxication, and only radiological recognition of the HBAS can propel the patient to appropriate recanalization therapy, i.e. intra-arterial thrombolysis (IAT) and/or intravenous thrombolysis (IVT).

SIGNIFICANCE

The HAS has always been associated with a poor clinical

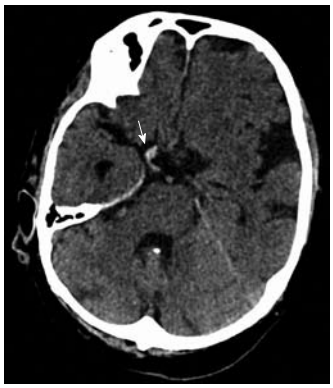

Figure 5 Hyperdense right fetal posterior cerebral artery (arrow) in a patient who presented with left sided homonymous hemianopia and left sided hemiparesis.

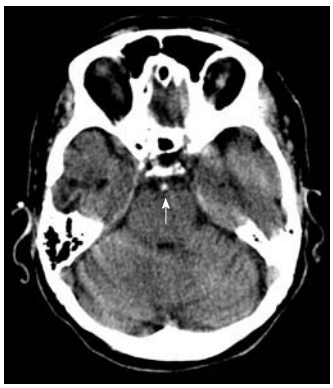

Figure 6 Hyperdense basilar artery (arrow) in a patient who was found unconscious.

outcome, large volume strokes, and severe neurological deficits[18]. This is probably caused by larger amounts of thrombus becoming visible on NECCT as an HAS, whereas smaller clots are invisible due to partial volume effects. Some studies have reported on the benefit of IVT in patients exhibiting a HAS[14-17], while others do not[18-22]. Two studies suggested that patients with a HAS benefited more from IAT as opposed to IVT[23,24]. This observation is in line with the afore-mentioned hypothesis that only large amounts of thrombus are visible on NECCT. What has prevented the HAS from becoming a more reliable marker of acute ischemic stroke is the fact that despite its high specificity it displays a low sensitivity of around 30%[25]. The reason for that is probably because of the large slice thickness in routine NECCT compared to the size of the vessels in question. On routine NECCT a slice thickness of 5 mm is not uncommon, while the MCA has a diameter of 2-3 mm. This discrepancy results in partial volume effects which blur the intraluminal hyperdensity. Two recent studies[37,38] examined the value of thin slice NECCT reconstructed on multidetector CT. The results in both studies were a striking rise in sensitivity to approximately 80%-100%. Riedel *et al*[38] also found a good correlation between vessel hyperdensity and thrombus volume when compared to computed tomography angiography (CTA).

FUTURE QUESTIONS

If NECCT is capable of reliably detecting thrombus, an interesting question for future studies may be: is there a cut-off value for the length of intraluminal thrombus beyond which IVT proves ineffective? In these cases, IAT may be the therapeutic option of choice. A further question is whether it is possible to automatically detect thrombus and measure its amount? NECCT would be a powerful and widely available tool to address these issues. Therefore, ideally prospective studies including patients suffering from acute ischemic stroke should compare luminal contrast gaps due to intravascular clots as detected in CTA images with thin slice NECCT images showing thrombus as an HAS. In order to find a threshold of clot burden beyond which it is not possible to recanalize occluded vessels by IVT, the patients would have to be followed by imaging studies (either MRA, CTA or transcranial ultrasound) at a fixed time interval after therapy in order to investigate if the recanalization was successful or if it failed.

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ORIGINAL ARTICLE

Percutaneous imaging-guided interventions for acute biliary disorders in high surgical risk patients

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Abstract

AIM: To evaluate the efficacy of percutaneous imaging-guided biliary interventions in the management of acute biliary disorders in high surgical risk patients.

METHODS: One hundred and twenty two patients underwent 139 percutaneous imaging-guided biliary interventions during the period between January 2007 to December 2009. The patients included 73 women and 49 men with a mean age of 61 years (range 35-90 years). Fifty nine patients had acute biliary obstruction, 26 patients had acute biliary infection and 37 patients had abnormal collections. The procedures were performed under computed tomography (CT)- (73 patients), sonographic- (41 patients), and fluoroscopic-guidance (25 patients). Success rates and complications were determined. The χ^2 test with Yates' correction for continuity was applied to compare between these procedures. A P value < 0.05 was considered significant.

RESULTS: The success rates for draining acute biliary obstruction under CT- , fluoroscopy- or ultrasound-guidance were 93.3%, 62.5% and 46.1%, respectively with significant P values (P = 0.026 and 0.002, respectively). In acute biliary infection, successful drainage was achieved in 22 patients (84.6%). The success rates in patients drained under ultrasound- and CT-guidance were 46.1% and 88.8%, respectively and drainage under CT-guidance was significantly higher (P = 0.0293). In 13 patients with bilomas, percutaneous drainage was successful in 11 patients (84.6%). Ten out of 12 cases with hepatic abscesses were drained with a success rate of 83.3%. In addition, the success rate of drainage in 12 cases with pancreatic pseudocysts was 83.3%. The reported complications were two deaths, four major and seven minor complications.

CONCLUSION: Percutaneous imaging-guided biliary interventions help to promptly diagnose and effectively treat acute biliary disorders. They either cure the disorders or relieve sepsis and jaundice before operations.

Key words: Biliary drainage; Biliary obstruction; Biliary sepsis; Cholecystostomy; Interventional radiology

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INTRODUCTION

Acute disorders of the biliary tract affect a significant portion of the population. These conditions include biliary obstruction, biliary sepsis, hepato-biliary trauma, and their complications. Over the past few decades, biliary interventions have evolved a great deal in diagnosing and managing patients with different biliary diseases, especially in critically ill patients who are unfit for any surgical intervention or induction of general anesthesia[1].

In most cases of acute biliary disorders, common cross-sectional imaging techniques such as ultrasonography (US), computed tomography (CT) or magnetic resonance cholangio-pancreatography are highly capable of depicting the diagnosis[2]. The two common procedures used to evaluate biliary anatomy are endoscopic retrograde cholangiopancreatography (ERCP) and percutaneous transhepatic cholangiography (PTC). A number of acute biliary disorders remain unexplained in critically ill patients as the clinical, radiologic, and biochemical features of the disorders are nonspecific in these patients. Currently, no single test is reliable for diagnosing acute biliary disorders in these patients. Usually those patients are surgically unfit and only interventional biliary procedures should be performed for diagnosis and management of such diseases.

Over the past three decades, endoscopic and percutaneous biliary interventions have become readily available in most hospitals, and these minimally invasive techniques have revolutionized the treatment of patients with acute biliary disorders. Today, imaging-guided percutaneous biliary interventions are safe and effective means for non-operative biliary decompression of biliary obstruction, sepsis and their complications as they can be performed with relative ease and carry a lower morbidity than surgical decompression. Percutaneous biliary drainage procedures can be lifesaving in many acute biliary disorders. These current percutaneous biliary interventions include PTC, external and internal biliary drainage (PTD) and percutaneous cholecystostomy. In addition, percutaneous treatment of biliary stone disease with or without choledochoscopy is still performed in selected cases. Other applications include cholangioplasty for biliary strictures, biopsy of biliary duct tumors, and management of complications from laparoscopic cholecystectomy, abdominal trauma, and liver transplantation[3-9].

Acute biliary disorders in critically ill patients are common in our tertiary care hospital. The clinical presentations of these conditions are often nonspecific and management by open surgery carries a high risk. Consequently, imaging-guided interventions are usually pivotal in the management of these patients. In this study, we illustrate the spectrum of acute biliary disorders in patients with high surgical risk and evaluate the success rate and complications of percutaneous imaging-guided interventions in their diagnosis and management.

MATERIALS AND METHODS

Patient population

This was a retrospective study from a tertiary care hospital.

Table 1 Clinical conditions leading to high surgical risk in 122 patients with acute biliary disorders *n* (%)

Condition	Patients
Advanced cardiovascular disease	24 (19.68)
Advanced multisystem disease	21 (17.22)
Advanced malignancy	19 (15.57)
Uncontrolled diabetes	14 (11.48)
Severe pancreatitis	12 (9.83)
Advanced respiratory disease	11 (9.01)
Advanced neurologic disease	9 (7.38)
Advanced liver disease	7 (5.74)
Morbid obesity	5 (4.09)
Total number of patients	122 (100)

The study was approved by the institutional review board. The records in our imaging database and medical files from Jan 2007 to Dec 2009 were reviewed for critically ill patients who underwent imaging-guided interventions for variable acute biliary disorders. The patient population included 122 patients; 73 women (60%) and 49 men (40%) with a mean age of 61 years (range 35-90 years). The patients had various clinical symptoms of acute biliary disorders including abdominal discomfort or pain, abdominal tenderness, fever, chills, and jaundice. These patients were of high surgical risk for different reasons (Table 1).

Imaging and interventional procedures

The patients were initially scanned by US using a 3.5 MHz convex probe (Voluson 730 Expert, GE, Austria) and CT scan was performed using a double and a 64-detector helical CT scanner (GE Healthcare). After written informed consent, different imaging-guided percutaneous biliary procedures were performed under CT guidance in 73 patients, sonographic guidance in 41 patients, and fluoroscopic guidance in 25 patients. Sonographic guidance was used whenever the dilated gallbladder, dilated biliary ducts or abdominal collections were obvious on sonography and a safe pathway could be documented for passage of the needle or catheter. CT-guidance was used for ductal puncture and immediate external drainage. After relief of obstruction and if internal drainage was needed, the procedure was performed within 3 d under fluoroscopic-guidance. We did not use CT fluoroscopy to guide the entire procedure. We prefer the use of percutaneous biliary interventions under CT-guidance to ensure immediate relief of obstruction and sepsis. In addition, a CT scan was carried out, whenever the clinical status did not improve after sonographic- and/or fluoroscopic-guided interventional procedures or when the draining catheter was not draining adequately.

PTC and PTD were performed in the standard fashion described elsewhere[3-5,10,11]. Under local anesthesia and intravenous sedation, a 22-gauge Chiba needle (Cook, Bloomington, MD, USA) was inserted. If drainage was required, a Jeifries set (Cook) was used to gain access to an appropriate duct. We use a small amount of dilute contrast media (5%) to prevent CT streaky artefacts and to prevent post-procedure sepsis.

Attempts to cross obstructions or strictures were made at initial drainage and subsequent sessions. The initial catheter guide-wire combination used for these attempts was a 5-F JB1 catheter (Cook) combined with a 0.035-inch angled guide-wire (Meditech/Boston Scientific, Watertown, Mass, USA), manipulated through the sheath of the Jeifries set. If this combination failed, other guide-wire and catheter combinations were tried. An 8-F Mueller drainage catheter (Cook) was placed in cases in which external drainage was required and an 8.3-F Ring catheter (Cook) in cases in which internal drainage was required. If a larger catheter was used at subsequent changes, a 10-F Percuflex VTCB catheter (Medi-tech/Boston Scientific) was inserted in place of the smaller catheter.

The technique of percutaneous cholecystostomy was used for high surgical risk patients with acute cholecystitis according to the technique first described by Radder[12] in 1980 and then modified by others in the following years[13-16]. In brief, the gallbladder is punctured using the Seldinger technique. Then, tract dilatation and catheter placement were performed using a guide-wire. The tract chosen depended on the anatomy and whether stone extraction was planned. The trans-hepatic route was preferred to the sub-hepatic route, as it carries less risk of bile leakage[17].

Drainage of intra-abdominal fluid collections was performed using US- or CT-guidance under local anesthesia, and intravenous sedation was used in some irritable patients. The procedure was performed as described elsewhere[18]. Briefly, after choosing a suitable needle track, an 18-gauge needle (Cook) was used to enter the collection and an 8-10-F APD drainage catheter (Meditech/Boston Scientific) was inserted into the collection with use of the Seldinger technique. Gravity drainage was used until the collection had resolved and drainage had ceased, at that point, the catheter was removed.

Data analysis and follow up

Success of the biliary intervention was achieved when there was clinical improvement, relief of obstruction or resolution of the collection on follow-up imaging. Failure was considered if biliary obstruction or collection did not improve with the intervention trial over at least 1 wk, or when the patient's clinical condition worsened despite optimal percutaneous management. The χ^2 test with Yates' correction for continuity was used to compare the differences in the success rate between the different procedures. A *P* value of less than 0.05 was considered significant.

RESULTS

The 122 patients were classified into three groups according to their clinical presentation (Table 2). One hundred and thirty nine different percutaneous imaging-guided biliary interventions were performed on these patients under CT- , US- and fluoroscopy-guidance (Table 3).

Of the patients in group 1, acute biliary obstruction was diagnosed in 59 cases. In this group, ERCP was able to demonstrate cause and level of obstruction in 21 patients (35.5%). ERCP failed to opacify the biliary tree in the remaining 38 patients (64.5%). In addition, the endoscopic intervention failed in 12 patients and the obstruction recurred in nine cases after endoscopic interventions. PTC was performed in these patients and biliary obstructions were located at the biliary bifurcation in 16 cases (27%), in the common extrahepatic bile duct in 29 cases (49%), the right hepatic duct in 8 cases (14%) and the left hepatic duct in 6 cases (10%). In this group, percutaneous imaging-guided drainage procedures were carried out under fluoroscopy- (Figure 1), US- or CT-guidance (Figure 2) with variable success rates as shown in Table 4. Additional catheters were used in 30 patients when the biliary dilatation was not communicating or the collections were either multiloculated or the initial catheter failed. Catheter upsizing was performed in 22 patients when the initial catheter was well positioned in the collection and still had low drainage rates of less than 10 mL/d.

Group 2 consisted of 26 patients with acute biliary sepsis as follow: acute cholangitis (6 cases), gallbladder empyema (3 cases), emphysematous cholecystitis (2 cases), acute cholecystitis (5 cases), and pericholecystic abscess (10 cases). Examples of these conditions are seen in Figures 3-7.

Table 2 Patient classification according to their clinical presentation *n* (%)

Group	Clinical presentation	Patients
Group 1	Acute biliary obstruction	59 (48.36)
Group 2	Acute biliary infection	26 (21.31)
Group 3	Abnormal intra-abdominal collections related to acute biliary tract disorders	37 (30.33)
Total		122

Table 3 Total numbers of the different imaging-guided interventional biliary procedures

	Type of procedure	Patients (*n*)
1	Computed tomography-guided biliary interventions	73
2	Ultrasonography-guided biliary interventions	41
3	Fluoroscopy-guided interventions	25
Total number of procedures		139

Table 4 Comparison between the different imaging-guided percutaneous drainage procedures and their success rate in patients with biliary obstruction

Type of procedure	No. of procedures	Successful procedures (*n*)	Success rate (%)
Fluoroscopy-guided drainage	16	10	62.5
US-guided drainage	13	7	46.15
CT-guided drainage	30	28	93.33[1]

[1]The success rate in patients drained by computed tomography (CT)-guidance was highly significant in comparison to ultrasonography (US)-guided drainage (P = 0.002) and to those drained under fluoroscopy (P = 0.026).

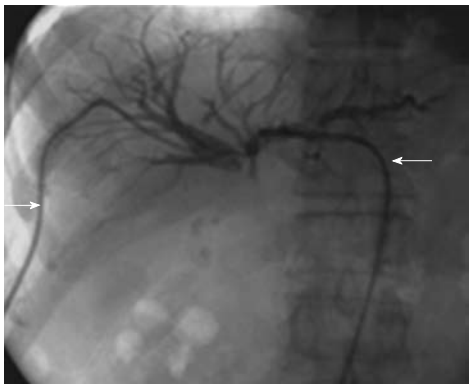

Figure 1 A case of malignant obstructive jaundice secondary to head of pancreas cancer. Fluoroscopy-guided right and left external drainage tubes are seen *in situ* (arrows).

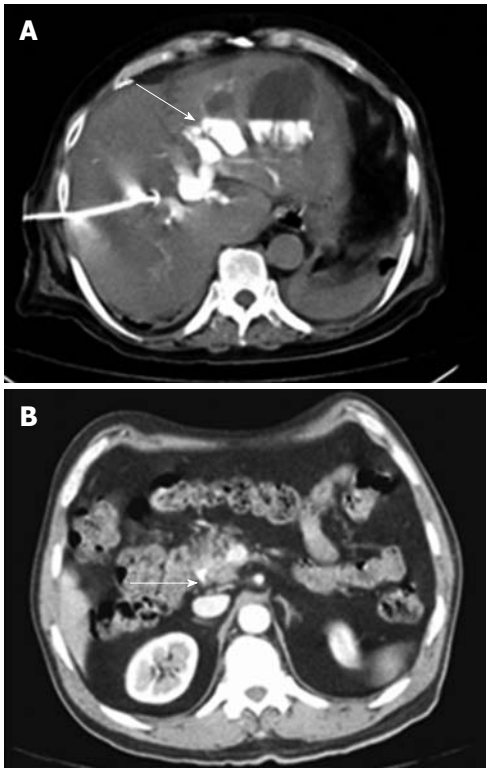

Figure 2 A case of obstructive jaundice secondary to head of pancreas cancer obstructing the common bile duct. A: Computed tomography (CT)-guided percutaneous transhepatic cholangiography shows opacification of markedly dilated intrahepatic biliary radicles (arrow); B: CT-guided internal drainage stent seen along the course of the common bile duct surrounded by the pancreatic mass (arrow).

Successful drainage in patients with biliary infection was achieved in 22 patients (84.6%). These patients were managed by either US +/- fluoroscopy- or CT-guided percutaneous drainage in conjunction with systemic antibiotics with different success rates as shown in Table 5.

Percutaneous drainage of intra-abdominal pathological fluid collections was performed in 37 cases (group 3) under US- or CT-guidance. In 13 patients with bilomas (Figure 8), percutaneous drainage was successful in 11 patients with a total success rate of 84.6%. In cases of

Table 5 Comparison between ultrasonography- and computed tomography-guided procedures in patients with acute biliary infection *n* (%)

Procedure	US-guided procedures		CT-guided procedures	
	No. of procedures	Successful procedures	No. of procedures	Successful procedures
Pericholecystic abscess drainage	5	2 (40)	7	6 (85.7)
Percutaneous cholecystostomy	5	3 (60)	5	5 (100)
Drainage for cholangitis	3	1 (33.3)	6	5 (83.3)
Total	13	6 (46.15)	18	16 (88.8)[1]

[1]The success rates in patients drained by computed tomography (CT)-guidance were significant compared with those drained under ultrasound guidance (P = 0.0293). US: Ultrasonography.

Table 6 Comparison between ultrasonography- and computed tomography-guided drainage procedures in patients with pathological intra-abdominal fluid collection

Type of collection	US-guided procedures		CT-guided procedures	
	No. of procedures	Successful procedures	No. of procedures	Successful procedures
Bilomas	4	2 (50)	10	9 (90)
Abscess	6	3 (50)	8	7 (87.5)
Pancreatic pseudocysts	5	3 (60)	7	7 (100)
Total	15	8 (53.33)	25	23 (92)[1]

[1]The success rates in patients drained by computed tomography (CT)-guidance were significant (P = 0.0145 < 0.05) compared with those drained under ultrasound guidance. US: Ultrasonography.

hepatic abscess (Figure 9) 10 out of 12 cases were drained successfully (83.3%). In 12 cases of pancreatic pseudocysts (Figure 10), successful drainage was achieved in 10 cases (83.3%). The details of the success rates of biliary interventions for drainage of abnormal fluid collections are shown in Table 6.

Post-procedure complications

Two deaths occurred within 30 d among the patients in this study resulting in a mortality rate of 1.6%. Four major procedure-related complications were seen; one case with pneumothorax that required insertion of an intercostal tube, another case had a duodenal perforation which was managed by insertion of a jejunal feeding tube, one patient had a hepatic hematoma that subsequently resolved and one patient had hepatic infarction. Minor complications in the form of immediate post-procedure sepsis were seen in seven patients.

DISCUSSION

Surgery is currently the accepted method of treatment for most cases of acute biliary tract disorders. However, sometimes a surgical approach may be technically difficult or associated with an unacceptable level of morbidity and

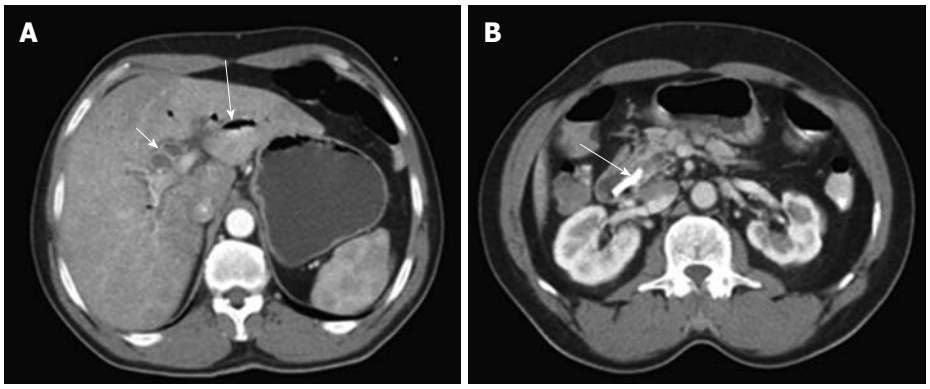

Figure 3 A case of acute cholangitis. A: Computed tomography (CT) scan shows pneumobilia (long arrow), dilated intrahepatic biliary radicles, with enhancing walls (short arrow); B: CT-guided internal drainage stent seen along the common bile duct (arrow).

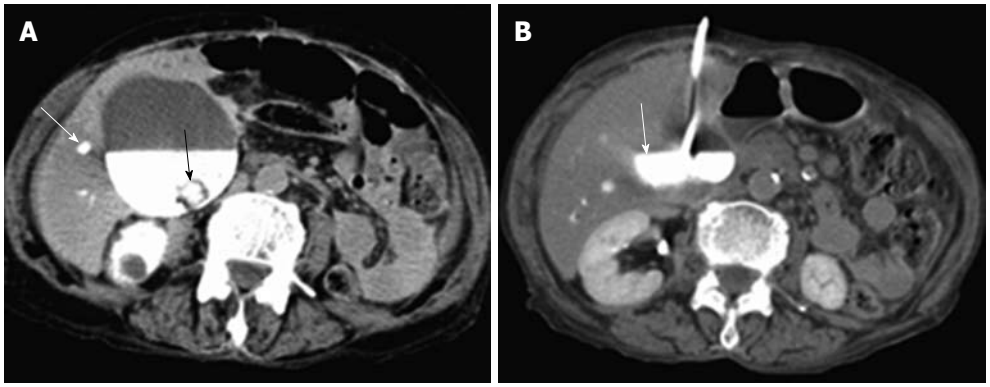

Figure 4 A case of gallbladder empyema. A: Computed tomography (CT)-guided cholecystostomy shows opacification of a markedly dilated gallbladder with intraluminal filling defect due to the presence of gallstones (black arrow). The intrahepatic biliary ducts (white arrow) were opacified after endoscopic retrograde cholangiopancreatography, which failed to drain the biliary ducts; B: Follow up CT scan shows well-drained gallbladder (arrow).

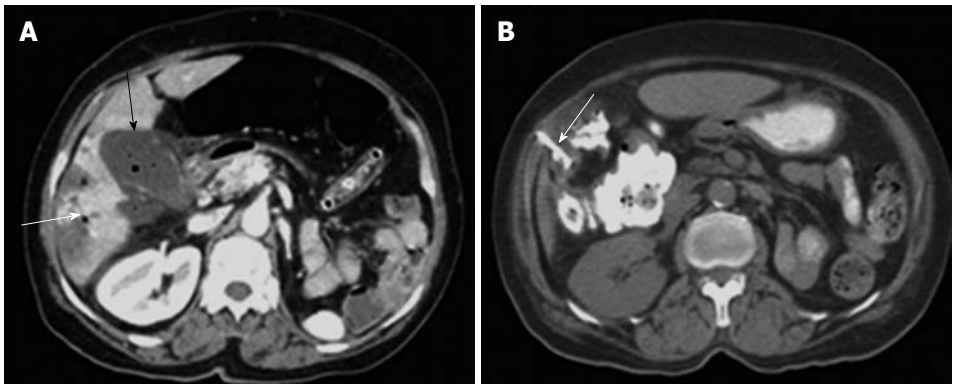

Figure 5 A case of emphysematous cholecystitis. A: Post contrast computed tomography (CT) scan shows thick-enhancing walled gallbladder with turbid fluid content and air loculi seen within its lumen (black arrow). Minimal free pericholecystic fluid collection. Pneumobilia seen within the intrahepatic biliary radicles (white arrow); B: Follow up CT-guided cholecystostomy with drainage catheter seen within the gallbladder lumen (arrow).

mortality. Such situations include emergency surgery in the elderly as well as elective surgery among high-risk patients. Percutaneous biliary intervention plays an important role in these conditions. It is considered a particularly valuable complement in patients who are not candidates for ERCP or surgery. Current percutaneous biliary interventions include PTC and biliary drainage to manage benign and malignant obstruction, and percutaneous cholecystostomy. Other applications include cholangioplasty for biliary strictures, biopsy of biliary duct masses, and management of complications from laparoscopic cholecystectomy and liver transplantation. In this study, we demonstrated the value of percutaneous imaging-guided biliary interventions in the management of three acute biliary disorders; acute biliary obstruction, acute biliary infection and abnormal intra-abdominal collections related to acute biliary tract disorders.

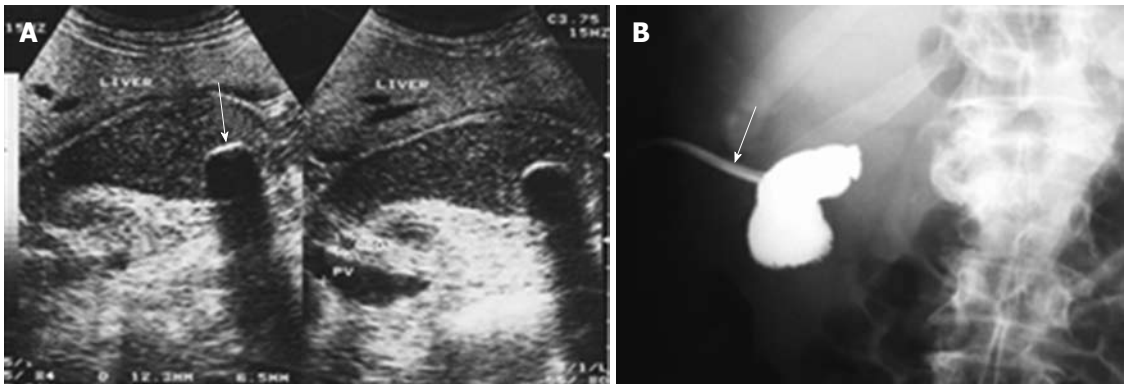

Figure 6 A case of acute calcular cholecystitis. A: Abdominal sonography shows thickening and stripping of its wall with stones and biliary mud seen within its lumen (arrow); B: Fluoroscopy image after ultrasonography-guided percutaneous cholecystostomy shows good position of the drainage tube (arrow).

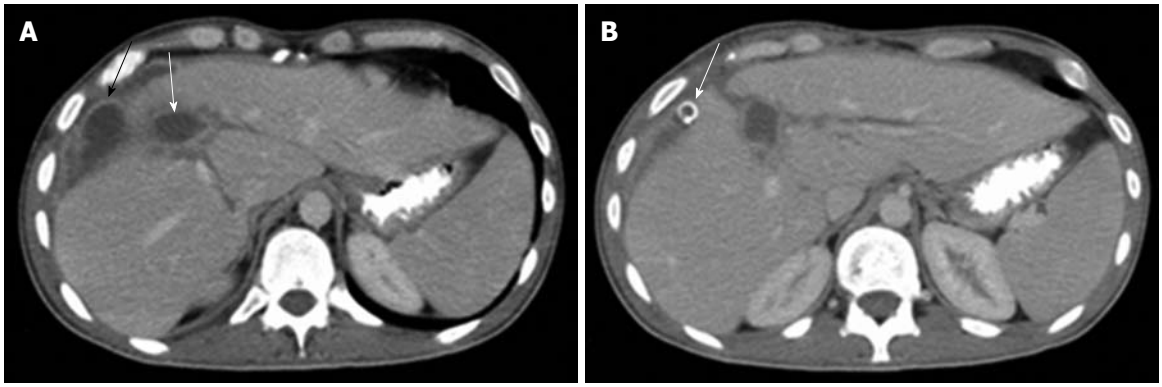

Figure 7 A case of acute cholecystitis with pericholecystic abscess. A: Computed tomography (CT) scan shows a pericholecystic abscess (black arrow) adjacent to acutely inflamed gallbladder (white arrow); B: Follow up after CT-guided drainage of the pericholecystic abscess shows marked resolution of the abscess with drainage tube seen within (arrow).

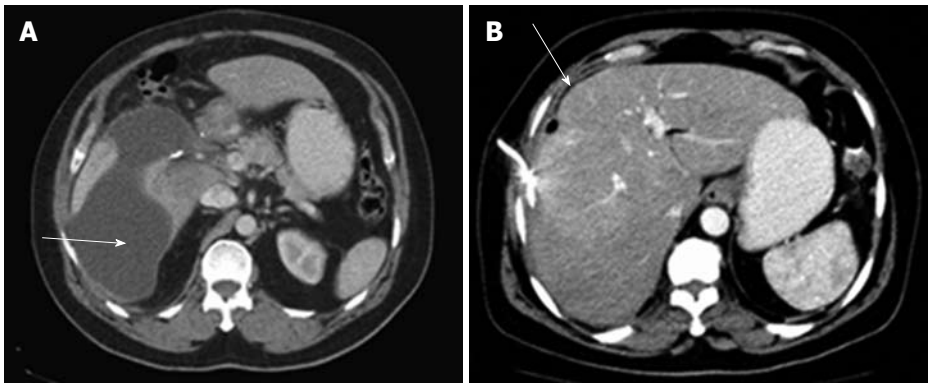

Figure 8 A case of post cholecystectomy biloma. A: Abdominal computed tomography (CT) shows a large subhepatic biloma (arrow); B: CT-guided drainage of the biloma shows marked regression of the volume of the collection (arrow).

In this work we evaluated the efficacy of 139 percutaneous imaging-guided biliary interventions in the management of acute biliary disorders in 122 high surgical risk patients. In 17 patients, more than one procedure was performed as in 2 cases of cholangitis where CT-guided drainage was performed after failure of US-guided drainage, or combined procedures such as combined US/fluoroscopy-guidance in 5 cases of percutaneous cholecystostomy.

In cases of biliary obstruction, ERCP usually allows visualization of the biliary tract but may not always fully depict the extent of a stricture, may neglect to show anomalous intrahepatic bile duct anatomy, and may not fully show the proximal biliary tree. In addition, induction of anesthesia is needed, which may not be suitable for some critically ill patients[19]. PTC is rarely needed to demonstrate the presence of an obstruction, but it is needed to accurately define the length of a stricture or of anomalous anatomy[20].

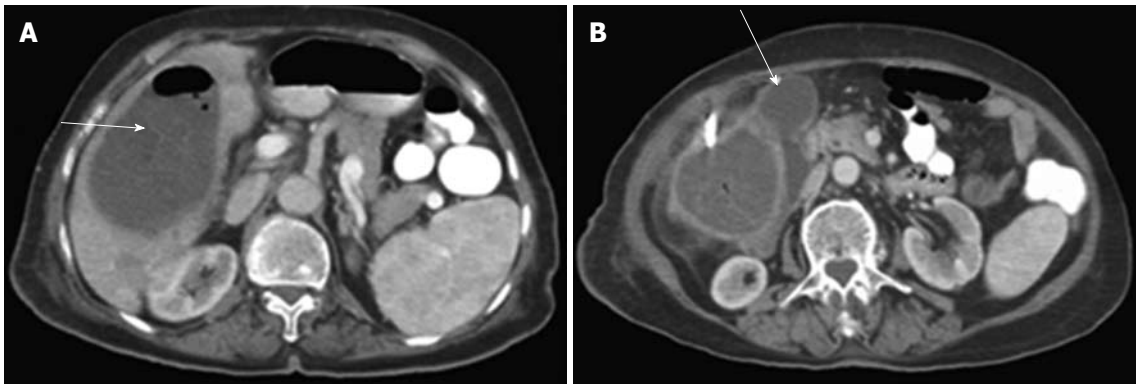

Figure 9 A case of acute cholecystitis complicated by hepatic abscess. A: Computed tomography (CT) scan shows a large intrahepatic abscess with air/fluid level within (arrow); B: CT-guided drainage of the hepatic abscess which is seen adjacent to acute cholecystitis (arrow).

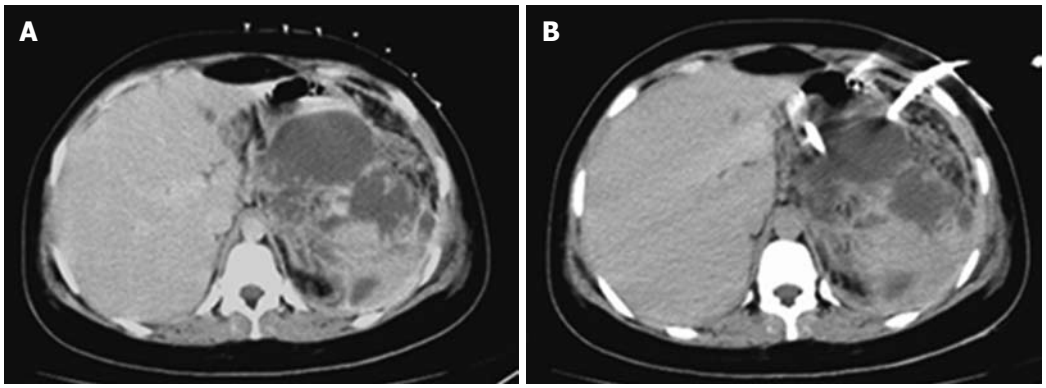

Figure 10 A case of pseudopancreatic cyst secondary to biliary pancreatitis. A: Computed tomography (CT) scan shows a large multilocular pseudopancreatic cyst with localized skin grid seen over the skin before the drainage procedure; B: CT-guided drainage catheter seen within the cavity of the pseudopancreatic cyst.

Among 59 cases of acute biliary obstruction in this study, ERCP was the first imaging modality to opacify the biliary tree. The preceding ERCP was able to demonstrate the cause and level of obstruction in 21 patients (35.5%) and failed to opacify the biliary tree in the remaining 38 patients (64.5%). This relatively high failure rate of ERCP was explained later by reviewing the results of PTC, which showed a high level of obstruction (bifurcational and supra-bifurcational) in 30 patients (51% of cases). Our results confirm the advantage of PTC over ERCP in the diagnosis of high-level biliary obstruction where the obstructing lesion prevents contrast material from opacifying the cephalic portions of the biliary system[21]. In another eight patients, the cause of failure of ERCP was the presence of a previous history of anatomy-altering surgeries (Billroth Ⅱ procedure) which make using an endoscope to cannulate the ampulla difficult. This observation is consistent with that in the study by Faylona *et al*[22] in 1999, who noted that successful selective cannulation during ERCP, was achieved in only 66% of attempts in patients with anatomy-altering surgeries. The role of biliary decompression in patients with acute biliary obstruction is well known. In addition to relief of pain and pruritus, it also prevents the development of further biliary complications. In addition, preoperative placement of a biliary drainage catheter provides an important intraoperative landmark to define the anatomy preoperatively and provide postoperative stent management[23].

In this study, after demonstrating the cause, level, and extent of biliary obstruction, PTD procedures were carried out under fluoroscopy- , US- and CT-guidance. We noticed that the success rates in patients drained by CT-guidance were higher (93.3%) compared to those drained under fluoroscopy or ultrasound-guidance (62.5% and 46.1%, respectively) with significant *P* values ($P = 0.026$ and 0.002, respectively). CT-guidance was used for ductal puncture followed by immediate external biliary drainage. We prefer the use of percutaneous biliary interventions under CT-guidance to ensure immediate relief of obstruction and sepsis, and this may explain why we had a high number of patients in our study who were managed under CT-guidance in contrast to the literature where US-guidance is the predominant modality used for guidance. This can be explained by the fact that under CT-guidance, the bile ducts can be punctured easily and more selectively with precise placement of drainage catheters within the pre-selected sub-segmental bile ducts. This conclusion is supported by the study of Froelich *et al*[24] who stated that CT facilitates percutaneous biliary drainage procedures and is superior to conventional fluoroscopically-guided biliary interventions because the number of hepatic punctures, procedure times, and radiation exposure times are

significantly reduced. They also concluded that because the number of hepatic punctures can be reduced and bile ducts can be punctured more selectively, procedure-related safety may be improved with decreased complication rates. Safety during the procedure and decreased post-procedure complications are important targets in managing critically ill patients.

Acute biliary infection is a serious clinical problem, especially in elderly and critically ill patients and immediate drainage of the biliary tree is essential. Management of acute biliary infection can be performed by means of surgical, endoscopic, or percutaneous interventional procedures. Emergency surgery in these patients is associated with unacceptable morbidity and mortality. Endoscopic papillotomy and duct clearance or placement of a stent can be life-saving in these conditions. However, endoscopic interventions are unsuccessful in 10%-15% of cases due to duodenal diverticula, edema of the papilla, biliary strictures, large impacted stones or previous gastric surgery. Percutaneous transhepatic external biliary drainage has few limitations and can be performed easily if the biliary tree is dilated[4].

In our study, percutaneous biliary drainage served as a diagnostic and therapeutic maneuver in 26 patients with acute biliary sepsis (group 2). These patients were managed either by US- or CT-guided percutaneous drainage in conjunction with systemic antibiotics. Biliary drainage in cases of biliary sepsis was successful in 22 patients with a total success rate of 84.6%. This success rate in the drainage of biliary sepsis is slightly lower than the results obtained in the study by Chopra *et al*[1], in which successful treatment of acute biliary inflammation was obtained in 52 of 53 (98.1%) of patients. On the other hand, our results are similar to another study comparing percutaneous drainage with surgery in the management of 66 critically ill patients with acute gallbladder sepsis, which concluded that percutaneous drainage has a relatively low complication rate and is rapidly effective[25]. These findings indicate that percutaneous imaging-guided biliary drainage is a useful therapeutic intervention for acute biliary sepsis in critically ill patients or patients unsuitable for immediate surgery.

We observed that the success rate in our patients drained under US-guidance (46.15%) was similar to another retrospective study performed by Andrén-Sandberg *et al*[26] in 2001 on the safety and efficacy of US-guided percutaneous drainage of the gallbladder in 86 patients with acute calcular cholecystitis. They observed that two thirds of their patients recovered within 36 h after the procedure and 27 (45%) of these were asymptomatic during the follow-up period for 6 mo. The success rate of drainage under US-guidance in our study was slightly lower than the results obtained by Cozzi *et al*[6] in 1999, who observed a dramatic improvement in the clinical condition of 48 out of 82 patients (59%) with gallbladder sepsis within 48 h after percutaneous cholecystostomy. In addition, our success rate was lower than that of Sosna *et al*[27] in 2004, who showed improvement in 30 (86%) of 35 patients who underwent US-guided percutaneous cholecystostomy. We think that our lower success rate was due to the specific nature of our patients who were critically-ill elderly patients. Also, we noted that our success rate of drainage under CT-guidance was higher than that under US-guidance and this can be explained by the same reasons mentioned previously regarding the advantages of CT-guidance of biliary drainage in cases of obstruction.

In recent years, the drainage of abnormal abdominal collections has been changed from surgical to nonsurgical management using imaging-guided catheter aspiration and drainage with antibiotic therapy, and are associated with high cure rates. The third group of patients in our study consisted of 37 cases with intra-abdominal pathological fluid collections (bilomas, hepatic abscess and pancreatic pseudocysts) as a complication of underlying acute biliary disorders such as biliary trauma, post-cholecystectomy complications, post-biliary interventions or following acute biliary pancreatitis.

For many years, interventional radiologists as well as endoscopists have also reported success with nonoperative therapy for bile leaks. Kaufman *et al*[28] treated 12 patients who had biliary leaks with percutaneous transhepatic biliary drainage. The biliary leaks healed in six patients, while surgery was required in five patients. Liguory *et al*[29] used percutaneous transhepatic biliary drainage in seven patients after failure of endoscopic biliary drainage and attained closure of the biliary leak in six patients. In our study, bilomas were detected in 13 high surgical risk patients as complications of biliary leak secondary to trauma, surgery, or previous intervention. Our success rate in the percutaneous management of bile duct injuries with bilomas was 84.6%. This result confirms the efficacy of percutaneous transhepatic biliary drainage in the treatment of bilomas. It is consistent with the results of Ernst *et al*[30] who reported complete cure of biliary leaks in 13 of 16 (81.2%) patients. Our success rate was higher than that in the study by Misra *et al*[31], who reported a 58.8% success rate in 51 patients with major bile duct stricture or injury without the need for subsequent intervention. The higher success rate in our study may be due to the limited number of patients.

Management of hepatic abscess has evolved rapidly during the past decade. For many years, the traditional treatment was surgical drainage. Imaging-guided percutaneous drainage, along with appropriate antibiotics, is an effective approach to treat hepatic abscesses. In our study, hepatic abscesses were drained percutaneously under CT and US-guidance in 12 patients with a total success rate of 83.3%. The percutaneous procedures were not curative in two of the 12 patients. Our success rate was higher than that of Mehendiratta *et al*[32] who reported cure of 67 of 92 (73%) abscesses managed by percutaneous aspiration without the need for open surgical drainage. The success rate of abscess drainage under CT-guidance in our study was 87.5% and was similar to that of Cinat *et al*[33] who showed resolution of hepatic abscess in 17 out of 20 patients with a success rate of 85% and that of Thomas *et al*[34] who showed resolution in 17/19 patients (89%).

The third subgroup of intra-abdominal collections in this study included 12 patients with pancreatic pseudocysts. Percutaneous or endoscopic drainage of peripancreatic fluid collections, pseudocysts, and abscesses have been well established as diagnostic and therapeutic standards in the management of acute pancreatitis[35]. In an older study, Heider *et al*[36] compared the success rates of surgical and percutaneous management of pancreatic pseudocysts. They observed that percutaneous drainage was successful only in 42% and surgical treatment was successful in 88%. They also noted that percutaneous drainage was also associated with a high death rate (16% *vs* 0%) and a high rate of complications (64% *vs* 27%). The low success rate of percutaneous drainage in their study may be related to the nature of unselected patients in their study and the lack of recently developed catheters and tubes. In most of the recent studies, the success rates of percutaneous drainage were higher. In the study by Nealon *et al*[37], 50 patients with a diagnosis of pancreatic pseudocysts had percutaneous drainage and 37 (74%) of them responded to this treatment. In another study, percutaneous external drainage was successful in two of three patients with pancreatic pseudocysts. They concluded that percutaneous external drainage is a good first choice for patients with unilocular pancreatic pseudocysts[38]. This conclusion is clearer in our current study, where the total clinical success rate of percutaneous catheter drainage was 83.3% (10/12) in these patients. The success rate under CT-guidance was 100%, this is consistent with the conclusion of Ferrucci *et al*[39] who reported that imaging guidance is best performed under CT control which allows precise definition of access route, catheter placement, and response. With regard to access, routes are chosen to avoid traversing vital intervening structures, especially the pleural space, colon, and small bowel.

Although imaging-guided percutaneous interventions appear safe and relatively simple, they are not completely free of risk. Two deaths occurred within 30 d among the patients in this study resulting in a mortality rate of 1.6%. This mortality rate was similar to that in the study by van-Sonnenberg *et al*[19], who reported a 2.2% mortality rate following 104 interventional procedures in 45 patients who underwent cholecystostomy. In the present study, we also reported acceptable procedure-related complications (four major and seven minor) in 11 patients (9%).

In conclusion, percutaneous imaging-guided interventional biliary procedures help to promptly diagnose and effectively treat major acute biliary disorders such as acute biliary obstruction, acute biliary infection, and abnormal intra-abdominal collections related to acute biliary tract disorders. These interventional procedures can either cure the disorder with a high success rate and obviate surgery or aid the surgeon by relieving sepsis and jaundice before operation when the clinical condition of these patients improve. In these conditions, the success rate is sufficiently high to justify the use of percutaneous intervention procedures as the technique of choice in the management of high surgical risk patients with acute biliary disorders. To increase the effectiveness of the procedure, we need to improve our criteria in patient selection, choice, and performing the procedure. Close follow-up, for monitoring and management of intervention-related problems is appropriate to avoid complications.

COMMENTS

Background

Acute disorders of the biliary tract affect a significant portion of the population. These conditions include biliary obstruction, biliary sepsis, hepato-biliary trauma, and their complications. In this study, we illustrate the spectrum of acute biliary disorders in patients with high surgical risk and evaluate the success rate and complications of percutaneous imaging-guided interventions in their diagnosis and management.

Research frontiers

Percutaneous imaging interventional procedures can either cure the disorder with a high success rate and obviate operation or aid the surgeon by relieving sepsis and jaundice before operation when the clinical condition of these patients improve

Innovations and breakthroughs

In our study, the success rate was sufficiently high to justify the use of percutaneous intervention procedures as the technique of choice in the management of high surgical risk patients with acute biliary disorders.

Applications

To increase the effectiveness of the procedure, we need to improve our criteria in patient selection, choice, and performing the procedure. Close follow-up, for monitoring and management of intervention-related problems is appropriate to avoid complications.

Terminology

Percutaneous imaging-guided interventional biliary procedures are imaging modalities like CT, US and fluoroscopy which are used to guide puncture of biliary ducts, collections or gallbladder and to guide manipulation of guide-wires, catheters and stents to ensure their correct position.

Peer review

Congratulations for discussing the role of interventions especially in surgically high risk individuals.

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BRIEF ARTICLE

Accessory spleen-like masses in oncology patients: Are they always benign?

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Abstract

AIM: To assess retrospectively the significance of accessory spleen-like mass (ASLM) in oncology patients undergoing positron emission tomography/computed tomography (PET/CT).

METHODS: The results of PET/CT of 913 patients (278 lymphoma; 635 solid tumors) were reviewed. The number, size, location and attenuation of all ASLMs, and spleen attenuation, were recorded. ASLM fluorodeoxyglucose uptake was graded as normal (less than or equal to that in the liver) or representative of malignancy (more than in the liver). Follow-up PET/CT in patients with ASLM was reviewed when available. ASLM size and attenuation for spleen and ASLM were compared by unpaired Student's *t* test. The χ^2 and Fisher's exact tests were used to compare ASLM frequency and uptake for lymphomatous and solid tumors, respectively.

RESULTS: ASLM frequency was 14.8%, with 152 ASLMs found in 135 patients. Mean attenuation was lower in ASLM compared with spleen by enhanced and non-enhanced CT (80.7 ± 20.4 HU *vs* 92.0 ± 14.4 HU, $P < 0.0011$ and 42.3 ± 9.0 HU *vs* 51.5 ± 6.3 HU, $P < 0.0001$, respectively). ASLM incidence was higher in lymphoma patients (56/278, 20.1%) than in those with solid tumors (56/278, 20.1% *vs* 79/635, 12.4%, $P = 0.0036$). Pathological uptake was found in four (7.1%) lymphoma patients but not in any patients with a solid tumor ($P = 0.028$) and it upstaged one patient with lymphoma. Follow-up PET/CT within 3-16 mo was available in 54% of patients with ASLM. Lesion regression was noted in all four pathological ASLMs on follow-up PET/CT after chemotherapy.

CONCLUSION: In patients with lymphoma, ASLM can represent malignancy, and thus further characterization with PET/CT might be warranted. Patients with neoplasia other than ASLM can be confidently diagnosed with accessory spleen.

Key words: Positron emission tomography/computed tomography; Lymphoma; Oncology; Accessory-Spleen

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INTRODUCTION

Accessory spleen (AS) is a congenital focus of healthy splenic tissue that is separated from the main body of the spleen. It is a frequently normal variant that is found in up

to 30% of cases at autopsy examination[1,2]. Most AS is asymptomatic and discovered incidentally during unrelated investigations[3]. The spleen is the largest single lymphatic organ in the body. AS can resemble a lymph node, both on computed tomography (CT) and macroscopically[3,4]. In a recent large study, AS was found in 15.6% of patients from a general population who were undergoing contrast-enhanced abdominal CT. They were recognized to have a distinct appearance on CT[5]. Most appeared as a well-marginated, round, oval or triangular mass, smaller than 2 cm, with attenuation similar to that of splenic tissue, and homogeneous enhancement on contrast-enhanced images[5]. Awareness of the characteristic CT appearance of AS is important for the radiologist to interpret CT studies correctly and avoid mistaking AS for a clinically significant abnormality[3,5].

The presence of AS might pose a problem in cancer patients who are evaluated by CT. AS can increase the suspicion of an enlarged lymph node in lymphoma patients, as well as for a solid tumor in the adrenal gland, pancreas, stomach or intestine, and even in the testes[6-9]. However in the most common location, near the hilum of the spleen or adjacent to the tail of the pancreas, a pathological lymph node or tumor can be mistaken as AS[5,10,11].

Combined positron emission tomography/CT (PET/CT) with 2-[^{18}F] fluoro-2-deoxy-D-glucose (FDG) is increasingly used for staging, restaging, and treatment monitoring in cancer patients. PET allows the detection of increased metabolic activity in tissue that can appear morphologically normal at CT[12], and therefore distinguish a malignant tumor from AS.

We retrospectively assessed the frequency and appearance of accessory spleen-like masses (ASLMs) in a large cohort of oncological patients who were referred for PET/CT. The combined value of FDG uptake and CT for differentiation of AS from tumor resembling AS was assessed.

MATERIALS AND METHODS

Patients

We retrospectively reviewed PET/CT performed in two separate medical centers during a 3-mo period (February-April 2007). Institutional ethics review board approval was obtained from both medical centers, and informed consent was waived. Databases of all PET/CT examinations performed in both centers were evaluated, and 915 consecutive patients with histopathologically proved malignancy in various stages of medical treatment were identified. Two patients were excluded due to previous splenectomy. The study included 913 patients (519 female, 394 male; mean age 61 years, range 11-89 years). Primary cancers included 278 lymphomas and 635 solid tumors, with colorectal, breast, and lung cancers being most common (Table 1).

Table 1 Tumor type and frequency of accessory spleen-like masses in 913 oncology patients undergoing 2-[^{18}F] fluoro-2-deoxy-D-glucose positron emission tomography/computed tomography *n* (%)

Tumor type	Patients	ASLM
Lymphoma	278 (30.4)	56 (41.5)
Colorectal	167 (18.3)	26 (19.3)
Breast	129 (14.1)	16 (11.8)
Lung	109 (11.9)	19 (14.1)
Gynecological	68 (7.4)	10 (7.4)
Melanoma	40 (4.4)	1 (0.7)
Stomach	33 (3.6)	0 (0)
Genitourinary	14 (1.5)	1 (0.7)
Others[1]	75 (8.4)	6 (4.4)
Total	913 (100)	135 (100)

[1]Thyroid, prostate, head and neck, unknown primary, sarcoma, gastrointestinal stromal, hepatocellular. ASLM: Accessory spleen-like mass.

PET/CT scanning

All studies were performed using an integrated PET/CT scanner (Discovery ST; GE Medical Systems, Milwaukee WI; or Gemini GXL; Philips Medical Systems, Cleveland, OH, USA). Preparation for PET/CT examination was similar in both centers and included fasting for at least 4 h before FDG administration. Patients were required to drink oral contrast medium (1 L of water with 30 mL Telebrix Gastro and ioxitalamate in a concentration of 300 mgI/mL; Guerbet, Roissy CDG, France). FDG dose varied from 370 to 666 MBq (10-18 mCi) according to patient weight, and was injected at 45-60 min before acquisition of emission images (PET).

Parameters for CT image acquisition were as follows: for Discovery PET/CT, spiral CT at 0.8 s per rotation with 100-300 mAs, 120 kVp, section thickness of 3.75 mm, and 3.75 mm interval. Intravenous contrast material was not administered. PET images were obtained using a weight-based protocol, with 3-4 min acquisition time per bed position. All PET images were reconstructed using an iterative algorithm, with CT-based attenuation correction applied. For Gemini PET/CT, CT parameters were as follows: 0.5 s per rotation with 80-200 mAs, 120 kVp, section thickness of 5 mm, and 2.5 mm interval. Iodine contrast media (Ultravist 300; iopromide 0.623 g/mL; Bayer Schering Pharma AG, Berlin, Germany; in a volume of 1.5 mL/kg) was intravenously administered. Patients with iodine allergy or chronic renal failure, and those who refused contrast, were examined with non-enhanced CT. Immediately after CT, a PET scan was performed. Acquisition time for the emission was 3-4 min per bed position with a one-section overlap. Six to eight bed positions from skull base to mid-thigh resulted in an acquisition time of 18-24 min. CT data were used for attenuation correction. Images were reconstructed using a standard iterative algorithm. Besides the use of intravenous contrast, there was no difference in the PET/CT techniques between the two centers.

Image interpretation

All CT, PET and fused PET/CT images were retrospectively examined. An ASLM was defined as a distinct well-marginated, round mass near to the spleen. Axial, coronal,

sagittal, and maximum intensity projections were viewed with AW-4.2 Workstation software (GE Medical Systems). The total number of ASLMs per patient, size (in the biggest dimension), location and CT attenuation of the spleen and the ASLM were recorded. Locations of the ASLMs were defined within discrete anatomical areas at the left upper quadrant. The spleen was divided craniocaudally into the upper (above the hilum), middle (hilum level) and lower third (below the hilum). On axial images, the space in front of the spleen was defined as anteromedial or anterolateral, and the space behind the spleen as posteromedial or posterolateral.

Visual analysis of FDG uptake in ASLM was assessed and graded from normal, defined as uptake less than or equal to uptake in the liver, to pathological, defined as intense uptake higher than that of the liver. ASLM with normal uptake was considered as an AS, whereas pathological uptake indicated malignant involvement of the ASLM[13]. Follow-up PET/CT was reviewed for patients with ASLM. ASLM was evaluated for stability or regression in size and uptake.

Statistical analysis

Values are expressed as mean ± SD (range). Size and attenuation measurements obtained by CT for the spleen and ASLM were compared using the unpaired Student's *t* test. The χ^2 test was used for comparison of ASLM frequency in patients with lymphomatous *vs* solid tumors. Fisher's exact test was used to compare the frequency of pathological ASLM in lymphomatous disease *vs* solid types of cancer. $P < 0.05$ was considered statistically significant.

RESULTS

The frequency of ASLM was 14.8%, with 152 ASLMs found in 135 of 913 patients. ASLMs were found in 76 female and 59 male patients with a mean age of 59.8 years (range: 11-89 years) (Table 1). In 18 patients, more than one ASLM was found, with a maximum of four ASLMs in a single patient. All ASLMs were round and well-marginated, with a mean size of 1.2 ± 0.46 cm (range: 0.5-2.9 cm). Only 13 (8.8%) were ⩾ 2.0 cm. The most common locations were anteromedial in the lower third (28.9%), anteromedial in the mid-third (19.7%), and anteromedial in the upper third (16.9%).

Mean attenuation for ASLMs was 80.7 ± 20.4 HU (range: 19.0-114.0 HU) in 55 contrast-enhanced CT examinations, and 42.3 ± 9.0 HU (range: 19.3-56.7 HU) in 80 non-enhanced CT studies. Mean attenuation in the spleen was higher both in contrast-enhanced (92.0 ± 14.4 HU, range: 46.0-127.0 HU, $P < 0.0011$) and non-enhanced CT (51.5 ± 6.3 HU, range: 39-91 HU, $P < 0.0001$) examinations, with the difference being statistically significant.

The incidence of ASLM in lymphomatous patients (56 out of 278) was significantly higher than in patients with solid tumors (79 out of 635) (20.1% and 12.4% respectively, $P = 0.0036$). Intense pathological uptake of FDG in an ASLM was found in four out of 56 (7.1%) lymphomatous patients and in none of the 79 patients with solid tumors ($P = 0.028$). In one patient, the finding of a positive ASLM changed the management of the disease by upstaging from stage 1 to stage 3 (Figure 1).

Additional interval PET/CT studies from 3 to 16 mo were obtained in 73 out of 135 (54%) patients with ASLM. In 69 patients (36 with solid tumors and 33 lymphomatous) without FDG uptake, there was no change in shape or size in the follow-up study, which confirmed the ASLM as an AS. All four lymphomatous patients with pathological FDG uptake in ASLM had regression of the disease demonstrated by PET/CT obtained after chemotherapy. In three patients, the ASLM vanished, which strongly suggested a diagnosis of pathological lymph node mimicking an AS. In one additional patient, there was intense pathological uptake of FDG in both the spleen and the ASLM. Lymphomatous involvement of the AS and the spleen was confirmed by stability of the size and location of the ASLM in subsequent PET/CT after chemotherapy, but without FDG uptake (Figure 2).

Three pathologic ASLMs were located anteromedially in the lower third area and one posterolaterally in the mid-third area. The mean size of the pathological ASLMs was larger than the normal ASLMs (1.8 ± 0.19 cm and 1.2 ± 0.46 cm respectively, $P < 0.001$), with the difference being statistically significant.

DISCUSSION

We found 152 round masses in the left upper quadrant with CT characteristics suggestive of an AS, in 135 out of 913 (14.8%) oncology patients referred for PET/CT. This is similar to the frequency (15.6%) of AS reported in a large general population referred for contrast-enhanced CT[5]. The significantly higher incidence of ASLM in lymphoma patients (20.1%) *vs* incidence in patients with solid tumors (12.4%) ($P = 0.0036$) was an unexpected finding. The higher incidence of ASLM in lymphomatous patients could be explained by lymphatic tissue activation, which might lead to an increase in the size of microscopic ASs previously not seen on conventional imaging. Furthermore, the incidence of pathological ASLM was significantly greater in lymphomatous than in solid tumor patients. ASLMs found in four out of 56 (7.1%) lymphoma patients demonstrated pathologically increased metabolic activity by intense FDG uptake, and changed the management in one patient. No pathological FDG uptake was seen in 79 ASLMs found in patients with solid tumors. By comparing PET/CT findings with previous examinations in the four lymphoma patients, we concluded that an AS was involved with lymphoma in one case, whereas three cases were found to be pathological lymph nodes mimicking a normal AS on CT.

The mean size of ASLMs with normal FDG uptake was significantly smaller than that of the pathological ASLMs. ASLM < 1.5 cm was always benign; however, the mean size of both normal and pathological ASLMs was < 2 cm. The most common anatomical location for ASs was

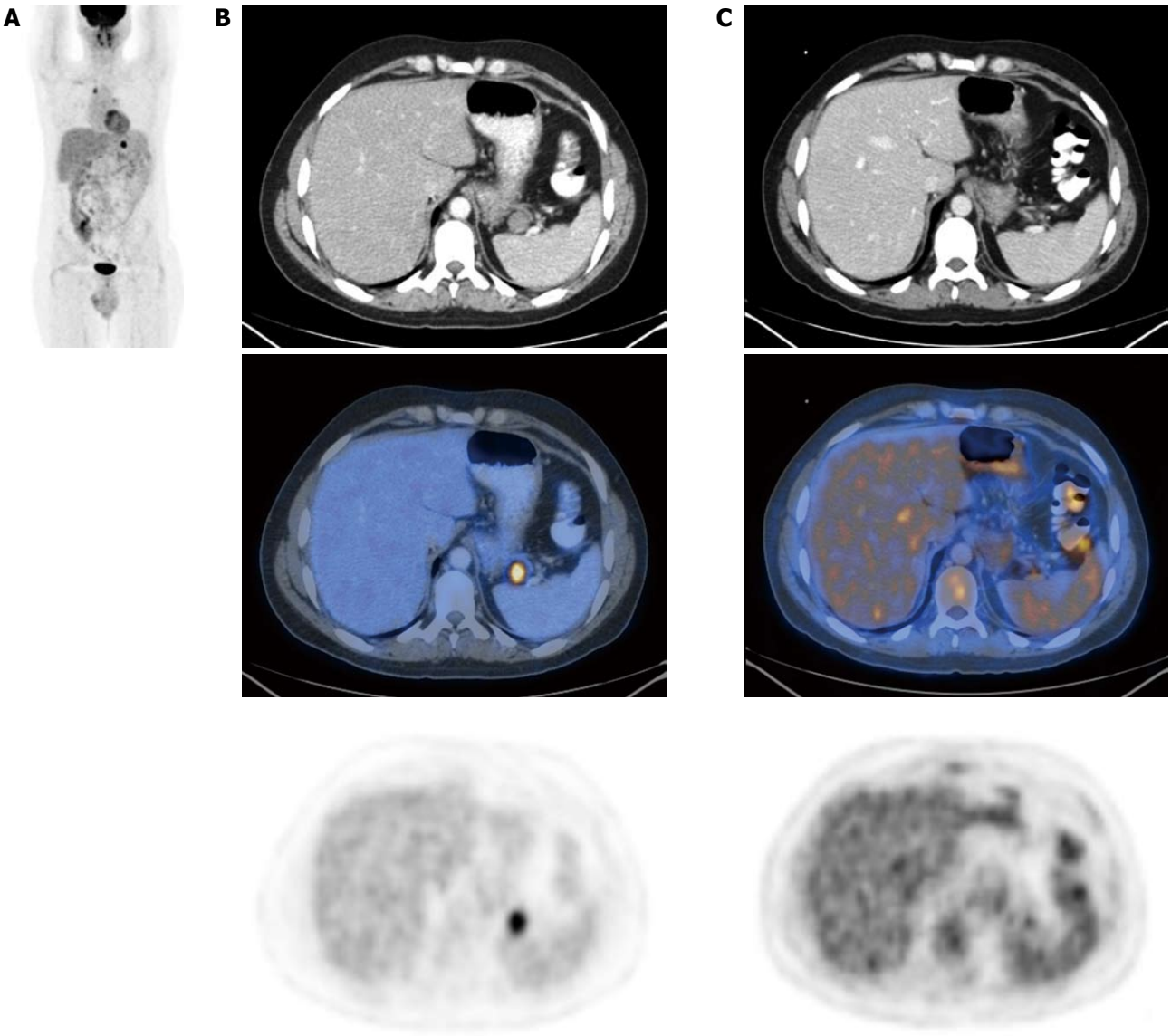

Figure 1 Pathological uptake of 2-[^{18}F] fluoro-2-deoxy-D-glucose in accessory spleen-like mass in a lymphoma patient. A: Positron emission tomography (PET) maximum intensity projection shows intense focal uptake in a mediastinal lymph node and in an accessory spleen-like mass (ASLM) in a 31-year-old man with Hodgkin's lymphoma; B: Transverse PET/computed tomography (CT) images show intense 2-[^{18}F] fluoro-2-deoxy-D-glucose uptake in the ASLM; C: Transverse PET/CT images obtained after treatment showing complete regression of the enlarged pathological lymph node.

Figure 2 Transverse positron emission tomography/computed tomography images show intense uptake of 2-[^{18}F] fluoro-2-deoxy-D-glucose in the spleen and accessory spleen, which corresponded to lymphomatous involvement in an 83-year-old woman with non-Hodgkin's lymphoma.

in the anteromedial lower third, as shown by Mortele *et al*[5]. The most common anatomical location of our small number of pathological ASLMs was also in the anteromedial lower third.

The combined PET/CT study provides important information that is not given by either modality alone. PET detects increased metabolic activity of glucose in tissue that can appear morphologically normal with CT, and therefore might be useful to differentiate benign from malignant lesions[12]. CT provides superior contrast and spatial resolution, with precise anatomical localization and attenuation measurements, but lacks functional information other than nonspecific contrast enhancement and washout. It has been proposed that ASs might be discriminated from pathological lymph nodes or a tumor in the splenic hilum when they enhance on CT to the same degree as the spleen[3,4]. In our study, there was a statistically significant difference in CT attenuation measurements for ASs and the spleen itself, both with and without contrast injection. This low attenuation in ASs has also been reported by Mortele *et al*[5], and they have suggested that partial volume effects can contribute to this apparently low attenuation because of the small size of these structures. Although the ASLMs have lower density, this is not a reliable sign of malignancy. All four pathological ASLMs detected by PET/CT had attenuation measurements similar to the ASs, and could be at first mistakenly interpreted as an AS based on the characteristic CT findings.

Other imaging techniques like magnetic resonance imaging (MRI) and ultrasound (US) cannot distinguish with high confidence between an AS and a pathological lymph node. The US echogenicity and MRI signal intensity and enhancement of the spleen on images obtained with various pulse sequences are determined by the high blood content, and the neoplastic tissue can resemble normal parenchyma[14-17]. Functional imaging with Tc-99m-labeled sulfur colloid, or Tc-99m-labeled, heat-denatured autologous red blood cells, has been shown to be useful in detecting splenic tissue and confirming the presence of an accessory or ectopic spleen[1,7,18].

The findings of our study could have clinical implications. Although PET/CT with FDG offers higher accuracy and sensitivity than PET or CT alone for lymphoma detection, the role of PET/CT for routine evaluation of lymphoma patients is still being defined[19,20]. Also, PET/CT is not available everywhere and CT is still usually performed in these patients. In lymphoma patients with ASLM on CT, further functional or metabolic imaging might be suggested to distinguish an AS from a pathological lymph node. In patients with other types of neoplasia, ASLM could be diagnosed as an AS.

Our study had some limitations. Low-grade lymphomas and some solid tumors might have low FDG activity, and thus FDG PET/CT could underestimate the real incidence of pathological ASLM. Functional imaging with radiocolloid or heat-denatured autologous red blood cells was not performed to confirm the presence of splenic tissue in all ASs. However, ASs were confirmed by sequential PET/CT imaging in more than half of the patients, and the lack of FDG uptake in the ASs was highly suggestive of a normal structure rather than a tumor. We combined data from two medical centers. Although the techniques varied with regard to intravenous use of iodine, all other portions of the PET/CT examinations were similar.

In conclusion, ASLM frequency in oncology patients is similar to the frequency published in the general population. It was higher in lymphomatous patients, of which about 7% showed malignant involvement. In lymphoma patients, awareness of an ASLM is important for the radiologist to interpret the CT findings correctly and raise the possible need to perform further functional or metabolic studies to avoid mistaking AS for a pathological mass. In patients with other types of neoplasia, ASLM can be confidently diagnosed as an AS.

COMMENTS

Background

Accessory spleen (AS) is a congenital focus of healthy splenic tissue that is separated from the main body of the spleen. It is a frequently normal variant found in up to 30% of cases at autopsy examination. Most ASs are asymptomatic, and discovered incidentally during unrelated investigations. The presence of an AS might pose a problem in cancer patients evaluated by computed tomography (CT). Combined positron emission tomography/CT (PET/CT) with 2-[^{18}F] fluoro-2-deoxy-D-glucose (FDG) is increasingly used for staging, restaging, and treatment monitoring in cancer patients. PET allows the detection of increased metabolic activity in tissue that can appear morphologically normal at CT, and therefore, distinguish a malignant tumor from AS.

Research frontiers

An assessment of the frequency and appearance of accessory spleen-like masses (ASLMs) in a large cohort of oncology patients referred for PET/CT. The combined value of FDG uptake and CT examinations for differentiation of AS from tumors that resemble AS was assessed.

Innovations and breakthroughs

In lymphoma patients, awareness of ASLMs is important for the radiologist to interpret the CT findings correctly, and raise the possible need to perform further functional or metabolic studies to avoid mistaking AS for a pathological mass. In patients with other types of neoplasia, ASLMs can be confidently diagnosed as AS.

Applications

An ASLM in an oncology patient can be confidently diagnosed as a splenule in non-lymphoma patients. In lymphoma patients PET/CT might be warranted for further characterization.

Terminology

An ASLM is defined as a distinct well-marginated, round mass near the spleen.

Peer review

This paper is very interesting and should be published because PET/CT of spleen-like masses could be an important subject in clinical routine work. Some improvements should be done.

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CASE REPORT

Arterio-biliary fistula as rare complication of chemoradiation therapy for intrahepatic cholangiocarcinoma

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Abstract

Significant hemobilia due to arterio-biliary fistula is a very rare complication of chemoradiation therapy (CRT) for unresectable intrahepatic cholangiocarcinoma (ICC). Here we report a case of arterio-biliary fistula after CRT for unresectable ICC demonstrated by angiographic examinations. This fistula was successfully treated by endovascular embolization. Hemobilia is a rare complication, but arterio-biliary fistula should be considered after CRT of ICC.

Key words: Arterio-biliary fistula; Intrahepatic cholangiocarcinoma; Endovascular embolization; Chemoradiation therapy; Hemobilia

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INTRODUCTION

Arterio-biliary fistula is a rare clinical condition resulting from various causes. Serious clinical symptoms occur due to shunting of high-pressure blood from the hepatic artery into the bile duct. Here, we report a case of arterio-biliary fistula after chemoradiation therapy (CRT) for unresectable intrahepatic cholangiocarcinoma (ICC) demonstrated by angiographic examinations.

CASE REPORT

A 78-year-old woman presented with obstructive jaundice. Computed tomography (CT) showed a tumor in the left lobe of the liver, which spread along the bile duct to the right hepatic bile duct. This tumor was diagnosed as cholangiocarcinoma, which had invaded the proper hepatic artery (Figure 1). Thus, we considered that this tumor was unable to be surgically resected, and percutaneous transhepatic biliary drainage (PTBD) was performed. After changing the PTBD tube to an internal-external biliary catheter, gemcitabine-based CRT (external beam radiation therapy; total dose 50 Gy) was administered. Chemotherapy was given in a palliative setting. Six months later, the tumor showed a partial response, but she developed tarry stools and was admitted for evaluation. Upper and lower gastrointestinal endoscopy showed no findings of tarry stool, but hemobilia was observed from the internal-external biliary catheter. Therefore, we performed arterial

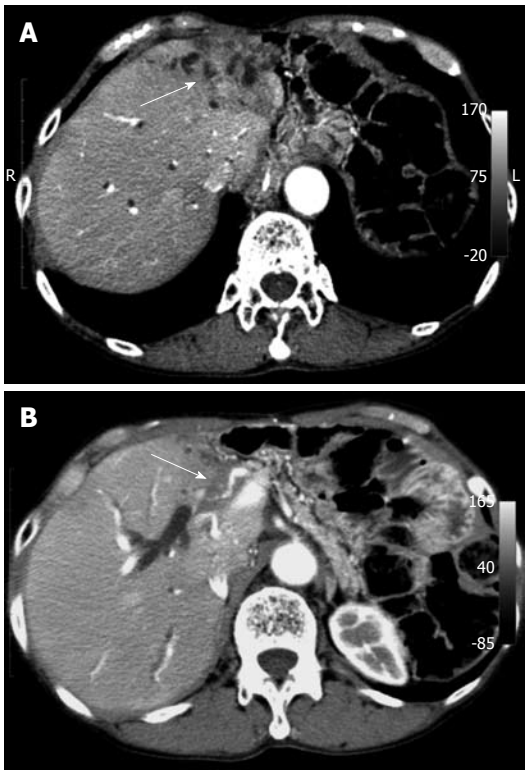

Figure 1 Abdominal computed tomography. A: Computed tomography computed tomography showing a tumor in the left lobe of the liver (arrow); B: This tumor invading the proper hepatic artery (arrow).

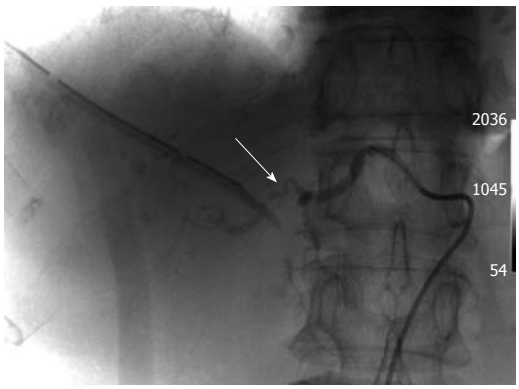

Figure 2 The arterial angiography reveals a fistula between the right hepatic artery and the right hepatic bile duct. The proximal region of irregular arterial wall of the right hepatic artery is some distance from the biliary catheter (arrow).

angiography, which revealed a fistula between the right hepatic artery and the right hepatic bile duct (Figure 2). Transcatheter embolization of the proper hepatic artery using microcoils was successful in stopping the hemobilia. After this event, the patient received chemotherapy, and subsequently showed no hemobilia or sign of recurrence.

DISCUSSION

Cholangiocarcinoma is a therapeutically challenging malignancy. The prognosis is typically poor. Multiple studies have demonstrated the potential efficacy of radiotherapy, with and without chemosensitization, as palliative therapy[1,2] and neoadjuvant therapy prior to conventional resection[3]. Recently, it was reported that liver transplantation with neoadjuvant CRT is more effective than resection for cholangiocarcinoma[4]. Thus, CRT for cholangiocarcinoma will become a major strategy for the treatment of this malignancy.

On the other hand, significant hemobilia due to arterio-biliary fistula is a very rare complication of CRT for ICC. There have been some reports of arterio-biliary fistula due to iatrogenic injury resulting from PTBD or hepatic biopsy[5,6]. However, arterial bleeding from a PTBD tract is very uncommon as a late complication[7,8], in contrast to the early phase after PTBD placement. In our patient, exchange of the internal-external biliary catheter had been performed prior to CRT with no bleeding, and arterio-biliary fistula occurred 6 mo after PTBD placement. In addition, the arterial angiography showed a region of irregular arterial wall of the right hepatic artery, but the proximal region of irregular arterial wall was some distance from the biliary catheter (Figure 2). Thus, we hypothesize that these facts suggest that transection of the hepatic artery by the biliary catheter was not the cause of the fistula, and we suspect that the tumoricidal depth of CRT beyond the thickness of the tumor resulted in damage of the right hepatic artery and fistula formation between the bile duct and the hepatic artery.

Transarterial embolization is considered the first line of intervention to stop the bleeding, since this interventional radiological procedure is minimally invasive, has a high success rate and a low incidence of complications compared to the more complex and dangerous surgical or laparoscopic options[9].

Arterio-biliary fistula is a very rare complication of CRT for ICC. However, the possibility of arterio-biliary fistula should be considered after CRT of ICC invading the hepatic artery.

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Meetings

Events Calendar 2010

January 4-8
Beaver Creek, Colorado, United States
18th Annual Winter Diagnostic Imaging Update

January 7-9
Leuven, Belgium
4th Leuven Course on Ear Imaging

January 16-17
Hollywood, Florida, United States
The Symposium on Clinical Interventional Oncology

January 17-21
Hollywood, Florida, United States
The International Symposium on Endovascular Therapy

January 21-22
Cairo, Egypt
BGICC Breast Gyne International Cancer Conference

January 21-24
Phoenix, AZ, United States
13th Society for Cardiovascular Magnetic Resonance (SCMR) Annual Scientific Sessions

January 23-23
Atlanta, GA, United States
Emory Winship Cancer Institute: Breast Cancer 2010: Advances in Science, Emerging Data, and Novel Therapeutics

January 25-29
Maui, HI, United States
Musculoskeletal & Neuroradiology MR Imaging Update in Maui

January 27-February 2
Albuquerque, NM, United States
2010 SNM Conjoint Mid-Winter Meetings

January 29-30
Barcelona, Spain
7th European Congress: Perspectives in Gynecologic Oncology

February 7-12
Vail, CO, United States
15th Annual Vail 2010: Multislice CT in Clinical Practice

February 11-13
Las Vegas, NV, United States
5th Annual Symposium on PET/CT and Molecular Imaging

February 16-19
Park City, UT, United States
6th Interventional/ Neurointerventional Conference

February 18-19
London, United Kingdom
Diagnostic and Interventional Radiology

February 18-21
Las Vegas, NV, United States
American Society of Spine Radiology Annual Symposium

February 20-20
Jacksonville, Florida, United States
Mayo Clinic Molecular Markers and Management of Breast Cancer

February 20-21
Bethesda, Maryland, United States
25th Anniversary Washington Neuroradiology Review

February 21-26
Orlando, FL, United States
The Abdominal Radiology Course

February 21-27
Snowmass, CO, United States
16th Annual Snowmass 2010: Clinical Ultrasound

February 22-26
Bethesda, MD, United States
48th Annual Dr. Kenneth M. Earle Memorial Neuropathology Review

February 24-27
Lake Buena Vista, FL, United States
ACRO 2010 American College of Radiation Oncology Symposium: Clinical Radiation Oncology Challenges

February 25-27
Chandler, AZ, United States
Multidisciplinary Head and Neck Cancer Symposium

February 26-27
Brussels, Belgium
10èmes Mises au Point en Imagerie Ostéo-Articulaire

February 27-March 1
Cairo, Egypt
7th Gastroenterology Hepatology & Endoscopy Symposium

February 28-March 4
Scottsdale, AZ, United States
International Congress XXIII on Endovascular Interventions

February 28-March 5
Breckenridge, CO, United States
5th Annual Breckenridge 2010: Musculoskeletal MRI

March 3-6
Las Vegas, Nevada, United States
11th Annual Advances in Breast Imaging and Interventions

March 4-8
Vienna, Austria
European Congress of Radiology (ECR 2010) Annual Meeting

March 5-7
Mt Tremblant, QC, Canada
Neuroimaging and Head & Neck Radiology Update in Mt Tremblant

March 7-11
San Diego, CA, United States
SCBT-MR Masters in Body Imaging: "What's New, What's Hot, What You May Not Have Known"

March 10-13
San Antonio, Texas, United States
Clinical Osteoporosis 2010: An ISCD-NOF Symposium

March 11-13
Barcelona, Spain
EORTC Group Meeting: EORTC Radiation Oncology Group

March 11-13
Hannover, Germany
40. Kongress der Deutschen Gesellschaft für Endoskopie und Bildgebende Verfahren e.V.

March 13-18
Tampa, FL, United states
Society of interventional radiology 35th Annual Scientific Meeting

March 14-17
Park City, UT, United States
14th Annual Park City 2010: MRI in Clinical Practice

March 22-26
Beaver Creek, CO, United States
NYU Radiology Spring Skiing Symposium in Beaver Creek

March 22-26
Maui, HI, United States
18th Annual Spring Diagnostic Imaging Update

March 24-27
San Diego, California, United States
2010 American institute of ultrasound in Medicine Annual Convention Preliminary Program

March 24-27
Barcelona, Spain
7th European Breast Cancer Conference

April 8-12
Shanghai, China
The 26th International Congress of Radiology

September 8-12
Guangzhou, China
Chinese Society of Interventional Radiology, 2010 CSIR

November 28-December 03
Chicago, United States
Radiological Society of North America: 2010 Annual Meeting

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Instructions to authors

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5 **Vallancien G**, Emberton M, Harving N, van Moorselaar RJ; Alf-One Study Group. Sexual dysfunction in 1, 274 European men suffering from lower urinary tract symptoms. *J Urol* 2003; **169**: 2257-2261 [PMID: 12771764 DOI:10.1097/01.ju.0000067940.76090.73]

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6 21st century heart solution may have a sting in the tail. *BMJ* 2002; **325**: 184 [PMID: 12142303 DOI:10.1136/bmj.325.7357.184]

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9 Outreach: Bringing HIV-positive individuals into care. *HRSA Careaction* 2002; 1-6 [PMID: 12154804]

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10 **Sherlock S**, Dooley J. Diseases of the liver and billiary system. 9th ed. Oxford: Blackwell Sci Pub, 1993: 258-296

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12 **Breedlove GK**, Schorfheide AM. Adolescent pregnancy. 2nd ed. Wieczorek RR, editor. White Plains (NY): March of Dimes Education Services, 2001: 20-34

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15 Morse SS. Factors in the emergence of infectious diseases. Emerg Infect Dis serial online, 1995-01-03, cited 1996-06-05; 1(1): 24 screens. Available from: URL: http://www.cdc.gov/ncidod/eid/index.htm

Patent (list all authors)

16 **Pagedas AC**, inventor; Ancel Surgical R&D Inc., assignee. Flexible endoscopic grasping and cutting device and positioning tool assembly. United States patent US 20020103498. 2002 Aug 1

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