ORIGINAL ARTICLE

Role of multidetector computed tomography (MDCT) in diagnosis and staging of gall bladder carcinoma

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Abstract  Background: Carcinoma of the gall bladder is the fifth most common malignancy of the gastrointestinal tract after colorectal, pancreatic, gastric and esophageal carcinomas.

Aim of the work: To study the role of multidetector computed tomography in the diagnosis and staging of gall bladder carcinoma.

Subjects and methods: This study included twenty-five patients presented to us during the period from June 2011 till May 2012 and were diagnosed radiologically by multidetector computed tomography as carcinoma of the gall bladder and the diagnosis was confirmed histopathologically. All the patients were subjected to ultrasonography followed by multidetector computed tomographic imaging using triphasic examination technique.

Results: Among the twenty-five patients included in this study there were fifteen females and ten males. Their ages ranged from 50 to 70 years old (average 60 years). All the patients were radiologically diagnosed as gall bladder carcinoma based on the multidetector computed tomographic findings. Infiltrating masses were detected in fifteen patients (60%), Intraluminal polypoidal masses were detected in nine patients (36%) while one patient (4%) presented with mural thickening of the gall bladder wall.

Conclusion: We conclude that multidetector CT is the diagnostic tool of choice in the detection and staging of gall bladder carcinoma.

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1. Introduction

Carcinoma of the gall bladder is the fifth most common malignancy of the gastrointestinal tract after colorectal, pancreatic, gastric and esophageal carcinomas. It is responsible for nearly 7000 deaths annually in the United States. It is found incidentally in 1–3% of cholecystectomy specimens and 0.5–7.4% of autopsies (1,2).
Risk factors for this neoplasm include gallstones (65–95%) and a history of chronic cholecystitis (40–50%), and an estimated 22% of patients with porcelain gallbladder will develop carcinoma (3).

Gallbladder carcinoma has a peak incidence in the sixth and seventh decades of life, and is three to five times more predominant in females. Native Americans, Spanish Americans in the southwest United States, and Eskimos have an increased risk for developing gall bladder cancer (4).

Early diagnosis of gallbladder carcinoma is difficult because most patients present with nonspecific findings of right upper quadrant pain, malaise, weight loss, jaundice, anorexia, and vomiting. This presentation is often confused with symptoms of acute cholecystitis or chronic cholecystitis (5,6).

Tumors confined to the gall bladder or with limited infiltration of the adjacent segments of the liver (segments V and IV) are considered resectable and are managed surgically by cholecystectomy and localized liver segmentectomy, however tumors invading other nearby organs or vessels, or associated with metastatic local lymph nodes away from the gall bladder, or with distant metastasis are considered inoperable. At the time of diagnosis, most patients are considered unresectable because of direct extension into adjacent organs, local lymph node metastasis, or distant metastatic disease. The 5-year survival rate for this tumor is less than 5%. Palliative surgery in the form of choledochojejunostomy could be sometimes performed in patients presenting with obstructive jaundice (7,8).

The major system used to describe the stages of gallbladder cancer is the American Joint Committee on Cancer (AJCC) TNM system (Table 1). This system is also used to stage cancers that start in the cystic duct (the tube that carries bile away from the gallbladder). This system is based on 3 key pieces of information: T describes how far the primary tumor has grown into the wall of the gallbladder and whether it has grown into other nearby organs or tissues. N describes whether the cancer has spread to nearby (regional) lymph nodes (bean-sized collections of immune system cells located throughout the body). M indicates whether the cancer has metastasized (spread) to distant organs of the body (1,9).

Ultrasound, CT, and MR are the primary means of imaging gallbladder carcinoma (9). This neoplasm has three major patterns of presentation pathologically and on cross-sectional imaging: (1) focal or diffuse mural thickening; (2) an intraluminal polypoid mass, usually larger than 2 cm, originating in the gallbladder wall; and (3) most commonly (45–65%) a subhepatic mass replacing or obscuring the gallbladder, often invading the adjacent liver parenchyma (8).

Higher resolution and more diagnostic images are now available after the recent advent of multidetector CT (MDCT). Transition from axial to single-slice helical to more recent MSCT scanners resulting in the reduction of imaging time from minutes to seconds with improved spatial and temporal resolution in all imaging planes. Although MSCT has had significant impact in evaluating the entire body, it has been particularly useful for abdominal imaging. Increased coverage is now obtained with thinner slices and higher image quality (8).

In this study, we will discuss and illustrate the multidetector row CT features of gall bladder carcinoma including patterns, extent and staging with impact of these data in the surgical evaluation and the management of these lesions.

2. Materials and methods

This study included twenty-five patients presented to us during the period from June 2011 till May 2012 and were diagnosed radiologically by multidetector computed tomography as carcinoma of the gall bladder and the diagnosis was confirmed histopathologically.

Clinical features, laboratory investigations and surgical findings were included in the study.

Ultrasoundography was performed before CT to all patients and its findings were included in the study.

Computed tomographic examination was performed from the level of the dome of the diaphragm through the pubic symphysis using a 16-slice CT scanner (Toshiba – Activion scanner). The protocol was as follows: 140 kVp; 350 mA; sections, 16; section thickness, 0.625 mm; pitch, 1.75; table speed, 35 mm/s (17.5 mm per rotation with two rotations); and gantry speed, 0.5 s per rotation. Triphasic CT examination was performed in all patients. Non contrast enhanced scans were performed, followed by contrast enhanced scans. Iopamidol (Isovue; Bracco Diagnostics, Princeton, NJ) was injected (Empower CT; E-Z-Em) at a dose of 150 mL (300 mg of iodine per milliliter) and a rate of 3 mL/s. Scanning was performed during the arterial and portal venous phases as determined with bolus tracking and automated triggering technology.

### Table 1

| Stage 0: Tis, N0, M0: | There is a small cancer only in the epithelial layer of the gallbladder. It has not spread outside the gallbladder |
| Stage I: T1 (a or b), N0, M0: | The tumor has grown into the lamina propria (T1a) or the muscle layer (T1b). It has not spread outside the gallbladder |
| Stage II: T2, N0, M0: | The tumor has grown into the perimuscular fibrous tissue (T2). It has not spread outside the gallbladder |
| Stage IIIA: T3, N0, M0: | The tumor extends through the serosa layer and/or directly grows into the liver and/or one other nearby structure (T3). It has not spread to lymph nodes or to tissues or organs far away from the gallbladder |
| Stage IIIB: T1 to T3, N1, M0: | The tumor has spread to nearby lymph nodes (N1) (Metastasis in cystic duct, pericholedochal, or hilar lymph nodes), but it has not invaded the main blood vessels leading to the liver or reached more than one nearby organ other than the liver. It has not spread to tissues or organs far away from the gallbladder |
| Stage IVA: T4, N0 or N1, M0: | The tumor invades the main blood vessels leading to the liver or has reached more than one nearby organ other than the liver (T4). It may or may not have spread to nearby lymph nodes. It has not spread to tissues or organs far away from the gallbladder |
| Stage IVB: Either of the following is true: Any T, N2, M0: | The main tumor may or may not have grown outside the gallbladder. It has spread to lymph nodes further away from the gallbladder (N2) including metastasis in peripancreatic (head only), periudodenal, periportal, celiac, or superior mesenteric lymph nodes. It has not spread to tissues or organs far away from the gallbladder OR Any T, any N, M1: The main tumor may or may not have grown outside the gallbladder. It may or may not have spread to lymph nodes. The tumor has spread to tissues or organs far away from the gallbladder (M1) |
The region of interest (ROI) for automatic triggering was in the abdominal aorta with a required density of 160 HU for starting of scanning in the arterial phase with 60 s delay for the portal venous phase. Delayed scans covering the liver and gall bladder fossa were also performed after 3 min. The transverse section data were reconstructed with 0.625-mm-thick sections at 0.625-mm intervals. The data were sent to the Vitrea workstation and coronal, sagittal, and curved multiplanar reformatted images were then obtained.

3. Results

Among the twenty-five patients included in this study there were fifteen females and ten males. Their ages ranged from 50 to 70 years old (average 60 years). All the patients (100%) presented with upper right abdominal pain. Ten patients (40%) presented with anorexia and fifteen patients (60%) had marked weight loss. Anemia was detected in twelve patients (48%) and jaundice was detected in eight patients (32%).

All the patients were radiologically diagnosed as gall bladder carcinoma based on the multidetector computed tomographic findings using triphasic technique. Infiltrating masses were detected in fifteen patients (60%). Intraluminal polypoidal masses were detected in nine patients (36%) while one patient (4%) presented with focal mural thickening of the gall bladder wall. Signs of associated chronic calculus cholecystitis were detected in ten patients (40%) while signs of associated acute cholecystitis partial perforation and hepatic abscess formation were detected in one patient (4%). Gall bladder stones were detected in ten patients (40%). Mild intrahepatic biliary dilatation was detected in six patients (24%).

Infiltrating gall bladder masses were detected in fifteen patients (60%). The preliminary diagnosis based on ultrasound findings done before CT examination was a hepatic mass in ten out of the fifteen patients with suggestion of mass originating from the gall bladder only in five patients. CT findings confirmed the origin of the masses to be from the gall bladder in all the fifteen patients, where the masses were seen violating the gall bladder wall. Infiltrating masses were also seen involving the adjacent portion of the gastric antrum and first part of the duodenum. This is associated with mild central intrahepatic biliary dilatation and multiple enlarged lymph nodes are seen including the portal group, peripancreatic, and para aortic lymph nodes. Radiological diagnosis of infiltrating gall bladder carcinoma (Stage IVB (T3N2M0)) was suggested. Palliative surgery in the form of cholecystojejunostomy was performed.

Fig. 1  (A) A 65-year old female presenting with right upper abdominal pain, anorexia and jaundice. Multislice contrast enhanced CT images of the abdomen: axial (A) and coronal (B) images showing a sizable heterogeneously enhancing mass infiltrating the gall bladder as well as segment V of the right lobe of the liver (large white arrow in (A) & (B)) and the adjacent portion of the gastric antrum and first part of the duodenum. This is associated with mild central intrahepatic biliary dilatation (small white arrow in (B)) and multiple enlarged lymph nodes are seen including the portal, peripancreatic, and para aortic lymph nodes. Radiological diagnosis of infiltrating gall bladder carcinoma (Stage IVB (T3N2M0)) was suggested. Palliative surgery in the form of cholecystojejunostomy was performed.

Fig. 2  (A) A 55-year old female presenting with right upper abdominal pain, weight loss and jaundice. Multislice contrast enhanced CT images of the abdomen: axial (A) and coronal (B) images showing a sizable heterogeneously enhancing mass infiltrating the gall bladder as well as segments V and IVB of the liver (large white arrow in (A) & (B)). Mild central intrahepatic biliary dilatation (small white arrow in (B)) and multiple enlarged lymph nodes are seen including the portal, peripancreatic, and para aortic lymph nodes. Invasion of the portal vein and hepatic artery is noted. Radiological diagnosis of infiltrating gall bladder carcinoma (Stage IVB (T4N2M0)) was suggested. The patient was treated with chemotherapy and no surgery was performed.
the gall bladder bed obscuring the gall bladder with an infiltration of segment V of the liver. Additional infiltration of segment IVB of the liver was detected in one patient (4%). Infiltration of the gastric antrum and duodenum was detected in two patients (8%). In all the patients the masses were initially hypodense to the hepatic parenchyma out of which nine had mild to moderate heterogeneous contrast enhancement in the portal venous phase of contrast enhancement while six showed no significant enhancement in either phase of contrast enhancement.

Intraluminal polypoidal masses were detected in nine patients (36%) all of which were detected by ultrasonography and confirmed by CT. The sizes of the polyps ranged from two to five centimeters and all showed moderate enhancement following intravenous contrast administration.

One patient (4%) presented with marked focal mural thickening of the gall bladder wall with encroachment upon its lumen and heterogeneous enhancement following intravenous contrast injection.

As regards metastatic lesions detected by CT, Enlarged metastatic abdominal lymph nodes were detected in eight patients (32%), metastatic hepatic deposits were detected in three patients (12%), metastatic pulmonary nodules were detected in two patients (8%) and metastatic osseous vertebral deposits were detected in one patient (4%).

As regards surgical management, cholecystectomy was performed to nine patients, cholecystectomy and localized segmentectomy of the liver were performed in seven patients while palliative surgery in the form of choledochojejunostomy (anastomosis between left hepatic duct and jejunum) was

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**Fig. 3** (A) A 53-year old male presenting with right upper abdominal pain, severe weight loss and jaundice. Multislice contrast enhanced CT images of the abdomen: axial (A) and coronal (B) images showing a polypoidal enhancing mass arising from the wall of the gall bladder wall and protruding into its lumen (large white arrow in (A) & (B)). Multiple metastatic liver deposits, mild intrahepatic biliary dilatation and enlarged lymph nodes including the portahepatis, celiac, pre and para aortic groups are seen in axial image (C). Metastatic osseous vertebral deposits are seen in the image (D) (small arrows) and metastatic pulmonary deposits are seen in the image (E) (small arrows). Radiological diagnosis of metastatic polypoidal gall bladder carcinoma (Stage IVB (T1,N2, and M1)) was suggested. The patient was treated with chemotherapy and no surgery was performed.
Fig. 4 (A) A 62-year old female presenting with right upper abdominal pain. Multislice contrast enhanced CT images of the abdomen: axial (A) and sagittal (B) images showing signs of chronic calcular cholecystitis in the form of thickened mildly enhancing wall and an intraluminal stone. It also shows an enhancing polypoidal mass partially occupying its lumen without signs of extension beyond the gall bladder or hepatic infiltration (arrows in (A) and (B)). No metastatic abdominal lymph nodes or distant metastatic lesions were detected. Radiological diagnosis of the polypoidal gall bladder carcinoma (Stage I (T1N0M0)) was suggested. The diagnosis was confirmed histopathologically after cholecystectomy.

Fig. 5 (A) A 67-year old male presenting with right upper abdominal pain, fever and jaundice. Multislice contrast enhanced CT images of the abdomen: axial (A) and sagittal images (C): showing a heterogeneously enhancing mass infiltrating the gall bladder wall as well as segment V of the right lobe of the liver (large white arrow in (A) and (C)) suggesting the radiological diagnosis of infiltrating gall bladder carcinoma (stage IIIA (T3N0M0)). Axial (B) and coronal (D) showed associated signs of edema of the wall of the gall bladder denoting associated acute cholecystitis and multiple intraluminal stones with signs of perforation and hepatic abscess formation in segment IV of the liver (large white arrow in (B) and (D)). Surgery was performed in the form of cholecystectomy with removal of segments V and IV of the liver and the diagnosis of carcinoma was proved histopathologically.
performed in six patients with advanced disease. Surgery was not performed in three patients with stage IV and they were only treated with chemotherapy after histopathological diagnosis via ultrasound guided tru-cut biopsy.

Figs. 1–6 show demonstration of the variable CT findings in six patients included in this study.

4. Discussion

This study included twenty-five patients presented to us during the period from June 2011 till May 2012 and were diagnosed radiologically by multidetector computed tomography (using triphasic CT examination) as carcinoma of the gall bladder and the diagnosis was confirmed histopathologically.

According to a prior autopsy study of patients with gallbladder cancer (2), the majority (68%) of gallbladder carcinomas are diffusely infiltrating lesions, whereas the remaining gallbladder carcinomas (32%) exhibit intraluminal papillary growth. Indeed, when gallbladder cancer manifests as wall thickening, it is challenging to diagnose because it mimics the appearance of more common acute and chronic inflammatory conditions of the gallbladder. In this study infiltrating masses were detected in fifteen patients (60%), Intraluminal polypoidal masses were detected in nine patients (36%) while one patient (4%) presented with focal mural thickening of the gall bladder wall.

Infiltrating gall bladder masses were detected in fifteen patients (60%) all of which were seen the invading segment V of the liver with the additional infiltration of segment IVB in one patient. Grand et al. (9) stated that contrast material enhanced CT in such cases may demonstrate a hypoattenuating or soattenuating mass in the gallbladder fossa and soft-tissue invasion of the liver, with a protrusion of the anterior surface of the medial segment of the left lobe. The tumor mass may contain low attenuation areas of necrosis while areas of enhancement reflect viable tumor. In this study in all of the fifteen patients presenting with such a pattern of gall bladder carcinoma the masses were initially hypodense to the liver tissue out of which nine had mild to moderate heterogeneous contrast enhancement in the portal venous phase of contrast enhancement while six showed no significant enhancement in either phase of contrast enhancement. The main goal of using triphasic CT examination in this study was to exclude the diagnosis of other hepatic masses with specific enhancement criteria like hepatocellular carcinoma. Absence of blush tumor enhancement in the arterial phase of enhancement and the rapid wash out of contrast in the venous and delayed phases of enhancement were important key diagnostic points in differentiating this type of infiltrating gall bladder tumor from primary hepatocellular carcinoma.

Intraluminal polypoidal masses were detected in nine patients (36%) all of which were detected by ultrasonography and confirmed by CT. The sizes of the polyps ranged from two to five centimeters and all showed moderate enhancement following intravenous contrast administration. According to Zissin et al. (10) the presence of a polypoidal intraluminal mass with fungating appearance and irregular borders is highly suggestive of gall bladder carcinoma, however the possibility of a soft stone, sludge ball and blood clot should be excluded. In the study soft tissue attenuation of the lesions and enhancement of the polypoidal lesions were the main key diagnostic features in suggesting the neoplastic nature of these lesions and all of them were confirmed histopathologically following cholecystectomy.

Based on a study performed by Soo et al. (11) on 78 patients presenting with wall thickening of the gall bladder using contrast enhanced multi detector computed tomographic study in the portal venous phase, two patterns of enhancement were significant predictors of malignancy, the first pattern was, two-layered wall thickening showing a strongly enhancing thick inner mucosal layer and a weakly enhancing or non-enhancing outer layer, while the second pattern was one-layer of wall thickening showing heterogeneous enhancement. Other benign patterns of wall enhancement suggesting benign conditions include a thin mildly enhancing inner layer and a non enhancing thin outer layer denoting chronic cholecystitis and, on the other hand a thin enhancing inner layer with a thick non enhancing outer layer denoting subserous edema due to acute cholecystitis. The presence of two enhancement-layer patterns with low attenuated foci within the inner layer suggesting dilated Rokitansky-Aschoff sinuses indicates the presence of adenomyomatosis (12). One patient presented in our study with irregular mural soft tissue thickening of the gall bladder wall showing one layer heterogeneous enhancement pattern.
and the radiological diagnosis of gall bladder carcinoma was suggested and confirmed histopathologically after cholecystectomy.

The sagittal and coronal reformatted images were very beneficial in this study in assessing the origin and extension of the gall bladder masses especially in the fifteen patients presenting with infiltrating masses. Confirmation of the origin of the mass from the gall bladder and the pattern of extension of the tumors beyond the confinement of the gall bladder with infiltration of the adjacent hepatic segments were better demonstrated in coronal and/or sagittal images (Figs. 1, 2B and 5C,D).

One of the main goals in this study was applying the TNM system for staging of gall bladder carcinoma in radiological evaluation of the patients included in the study which was very helpful in the planning of surgical or medical treatment following radiological diagnosis. Multidetector CT with its excellent multiplanar capability was able to detect direct hepatic infiltration in the fifteen patients presenting with diffusely infiltrating gall bladder masses. Local infiltration of the gastric antrum and duodenum was detected in two patients (8%). Enlarged metastatic abdominal lymph nodes were detected in eight patients (32%), metastatic hepatic deposits were detected in three patients (12%), metastatic pulmonary nodules were detected in two patients (8%) and metastatic osseous vertebral deposits were detected in one patient (4%). Cholecystectomy was performed in nine patients radiologically staged as stage I carcinoma. Cholecystectomy and localized segmentectomy of the liver were performed in seven patients with radiological staging as stage IIIA with limited hepatic infiltration. Palliative surgery for relief of biliary obstruction in the form of choledocho-jejunostomy (anastomosis between left hepatic duct and jejunum) was performed in six patients with radiological staging as stage IV. Surgery was not performed in three patients with stage IV and they were only treated with chemotherapy after histopathological diagnosis via ultrasound guided trucut biopsy.

Finally we conclude that multidetector CT is the diagnostic tool of choice in the detection and staging of gall bladder carcinoma, still the examination has to be reviewed by an experienced radiologist who is oriented with its different radiological patterns as well as with its different staging criteria and its patterns of spread which are essential for planning of the treatment.

References