

## CASE REPORT

# Spectral CT Detection of Entrapped Gallstone Based on Z-effective Map

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Gallstone disease and related cholecystitis are common clinical conditions for which ultrasound is the diagnostic method of choice. Computed Tomography (CT) can help in difficult and inconclusive cases. We present a case of a patient with a final diagnosis of an entrapped gallstone causing subacute cholecystitis, detected first with a spectral CT and the use of the mean atomic number display map of the gallbladder content.

**Keywords:** gallstone disease; tomography; X-ray computed; cholesterol gallstones; dual-energy CT; spectral CT; effective Z map

Diagnosis of gallbladder stone (GBS) is based on ultrasound (US), due to its high accuracy (98%) [1]. When cholecystitis is clinically suspected, US is also the preferred first diagnostic method, to identify signs of inflammation and the causative stone [2]. In inconclusive cases, computed tomography (CT) can be required to confirm or exclude cholecystitis, with a lower accuracy for stone detection, ranging from 25–88 % [3]. The most recent spectral CT systems (dual-energy or spectral systems) are based on the principle of image acquisition at two levels of energy (80 and 140 kVp). In vitro studies dedicated to GBS have demonstrated that higher voltages could help CT to detect more GBS. Some CT manufacturers have developed software solutions giving access to mean atomic number values of anatomic structures. Here we present a case of a patient with a final and diagnosis of entrapped gallstone causing subacute cholecystitis. This was detected first with spectral CT and the use of the mean atomic number display map of the gallbladder content.

### Clinical Case Story

A 49-year-old woman presented to the outpatient gastroenterology clinic for recurrent episodes of right upper quadrant pain beginning several weeks prior. The initial US, done one month before, was inconclusive. CT examination with intravenous iodine contrast injection (100 ml of Iobitridol 350 mg/ml) was performed on a spectral CT system (IQON CT, Philips Healthcare, Cleveland, OH, USA) equipped with two layers of detectors (sandwich configuration) capturing low- and high-energy photons respectively. The CT dose-length product (DLP) was 230.3 mGy/cm. Based on the conventional CT images, the diagnosis of dis-

crete gallbladder changes due to acute cholecystitis was made (discrete enlarged gallbladder, increased wall thickness (4 mm, nl < 3 mm), enhanced wall attenuation and peri-vesicular fat tissue infiltration) (**Figure 1a** and **b**). The cause of the gallbladder inflammation was not visible. The spectral data were analysed on a dedicated workstation and a round-shaped mass of 15 mm was identified within the neck of the gallbladder. The stone had the same color value and atomic number compared to the subcutaneous and retroperitoneal fat tissues (**Figure 2a**); retrospective analysis at 200 keV confirmed the presence of gallstone (**Figure 2b**). Based on surgery and histology, a final diagnosis of subacute cholecystitis due to an entrapped cholesterol stone was concluded.

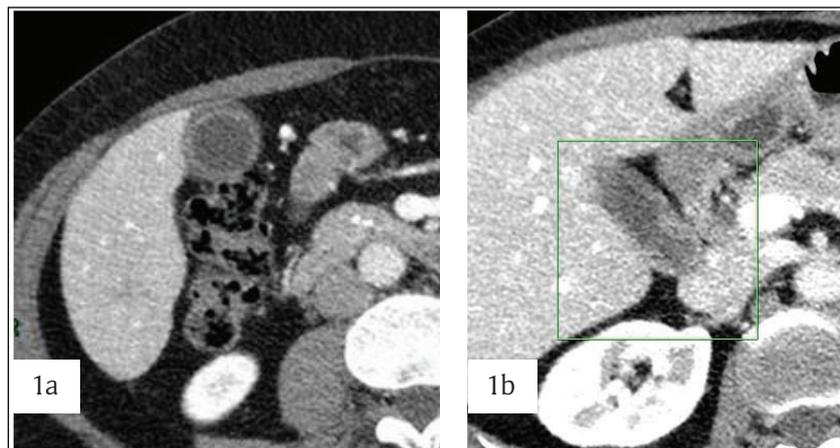
### Discussion

Most of the biliary and gallstones are composed of cholesterol material (pure or combined) and pigment stones [1, 4]. The detection rate of these stones on conventional CT is based on the kilovoltage of the CT system, and the attenuation of the stone (if there is enough amount of calcium and/or fat). The new generation CT (dual energy or spectral systems) use two different levels of energy (80 and 140 kVp). This option varies depending of the manufacturer: two X-ray tubes and opposing detectors working each at a separated level of energy (Siemens, Germany), or a single source CT with a fast kV switching X-ray tube between low- and high-energy voltage (GE Healthcare, USA), or one tube and two layers of detectors for low and high energies (Philips Healthcare, USA) [5]. We are using the latter system in our institution. This technology aims at obtaining datasets with two different photon spectra to determine the actual atomic number of the anatomical structures based on their attenuation at different energy levels [6]. When the CT is acquired after iodine contrast injection, virtual non-contrasted images (VNC) can also be computed. These VNC images have been recently vali-

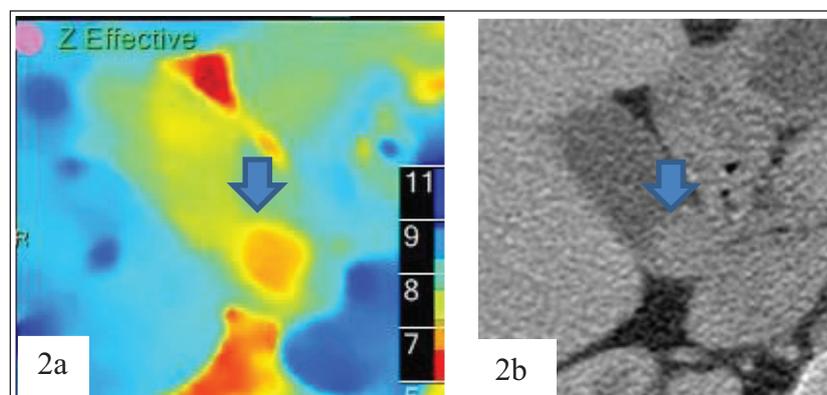
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**Figure 1 (a & b):** Conventional CT image with IV iodine injection shows discrete and diffuse thickening of the gallbladder wall.



**Figure 2:** Effective z-map of the mean atomic value of the gallbladder content **(a)** showed a mass of similar color compared to the retroperitoneal fat (arrow); and a 200 keV monochromatic reconstruction **(b)** showed a hyperattenuating round-shape structure (arrow), consistent with entrapped infundibular cholesterol gallstone (arrow).

dated for a better detection of gallbladder stones at different levels of energies, particularly the non-calcified forms [7, 8]. Some manufacturers have developed software solutions giving access to mean atomic values of the considered tissue [6]. On our system, this scale is converted in colors representing mean atomic tissue numbers from 6 or lower to 11 or higher. In our clinical setting, the cholesterol component of the impacted stone was quickly and promptly identified by using this z-atomic map, as it has recently been reported [9]. The capability of spectral CT to provide the tissue composition of several body materials has been demonstrated for kidney stones, separating urate stones from other forms. With this information, appropriate medical and nutritional treatments (dedicated drink water) can lead to the spontaneous dissolution. When extrapolated to cholesterol stone, if surgery has to be postponed, medical therapy with ursodeoxycholic acid could be an option, because it has been shown effective for cholesterol stone dissolution [4].

In the daily practice, US is still the primary imaging modality when GBS and acute cholecystitis are suspected [1, 2]. In an acute setting, doubtful or difficult cases on US are evaluated additionally with CT [10]. As in our case, the relevant contribution of spectral CT has been

demonstrated in the literature with a similar or a reduced radiation dose as compared to conventional CT [11, 12]. In such acute conditions, MRI is not the preferred method for the diagnosis of acute cholecystitis, but may contribute to detect entrapped choledocholithiasis and its related complications [10].

### Conclusion

This case report illustrates the capability of spectral CT to promptly detect initially missed gallbladder stones. This report could initiate large studies about the gallbladder contents with the use of recent spectral CT systems, based on their atomic number, in combination with the actual attenuation Hounsfield Units.

### Ethics and Consent

- No funding was received for this paper.
- All procedures performed in our case involving the human participant were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.
- Written informed consent was obtained from the pa-

tient for publication of this case report and any accompanying images.

### Competing Interests

The authors have no competing interests to declare.

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**How to cite this article:** Danse, E, Jamali, S and Hubert, C. Spectral CT Detection of Entrapped Gallstone Based on Z-effective Map. *Journal of the Belgian Society of Radiology.* 2018; 102(1): 53, 1–3. DOI: <https://doi.org/10.5334/jbsr.1515>

**Submitted:** 03 February 2018

**Accepted:** 15 August 2018

**Published:** 24 August 2018

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