

# The “Triple-Q Algorithm:” A practical approach to the identification of liver topography

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## ABSTRACT

The descriptive identification and interpretation of liver pathology continue to raise debate, especially for trainees and junior physicians. There is wide diversity in the description of liver segmentation with sometimes contradictory terminology between French and American literature. Attempts were made to create a unified nomenclature that simplifies the problem. We propose a simple approach to describe the location of liver pathology in different settings by referring to an algorithm based on three questions. Explanations to answer these questions and correctly describe the location of liver pathology are herein described. In conclusion, we think that the adoption of such an algorithm called arbitrary “the Triple-Q Algorithm” will facilitate the understanding of liver topography for the young physicians, as well as it will allow for the accurate description and localization of the pathological lesions in the liver. This could be achieved after testing and validating this algorithm in prospective studies. This could have academic and clinical implications in the medical education and the patient care.

**Key words:** Hepatic topography, liver segmentation, nomenclature of liver anatomy

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## INTRODUCTION

The liver occupies the right upper part of the peritoneal cavity. If the skin is considered to be a system of organs and not a single organ, then the liver will be the largest organ of the human body. It has an average weight of 1.5 kg which corresponds to 2–3% of the total body weight and receives 1.5 L/min of blood which corresponds to 25% of the total cardiac output.<sup>[1]</sup> It accumulates a large amount of blood per single unit of tissue that averages 30 ml for every

100 g of hepatic parenchyma that is why a complex and severe hepatic injury can be often fatal secondary to blood exsanguinations.<sup>[2]</sup>

Physicians all over the world and throughout the centuries have struggled to define its functional and surgical anatomy. What was once considered to be a single cohesive organ, turned out to be formed of multiple independent segments, which constitute each on its own, an isolated and functional “small liver.” Many papers and textbook chapters have tried to facilitate the understanding of liver topography; however, we still find that medical students and newly medical graduates and young physicians who do not deal with hepatobiliary pathologies on daily basis have difficulty

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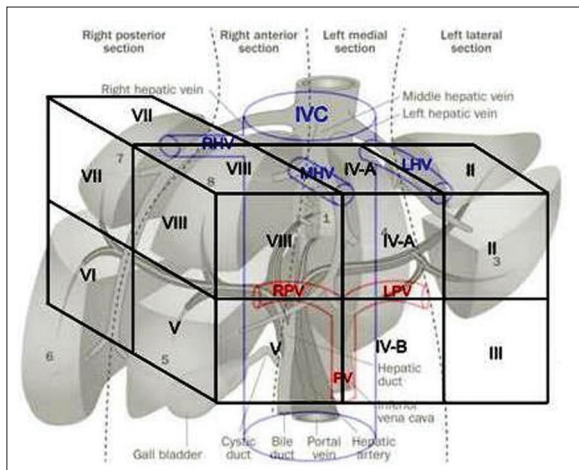
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to describe the location of a liver lesion in the context of neoplastic process or the liver injury on serial imaging.<sup>[3]</sup> The best imaging modality that clearly shows the different anatomical landmarks of the liver is by far the triphasic helical computed abdominal tomography (CAT scan) that is available nowadays in most hospitals. In a trial to simplify the interpretation of hepatic structures on CAT scans and intraoperatively, we came out with a simple and practical algorithm – called arbitrary “the Triple-Q Algorithm” that we think will facilitate the understanding and the accurate description of the localization of liver topography.

## THE TRIPLE-Q ALGORITHM

“The Triple-Q Algorithm” consists of three questions that correspond to the first, second, and third order of division of the portal triad. It will allow physicians, based on specific defined landmarks that are easily detected on CAT scan, to answer the first question (Q1) and describe in which lobe a liver pathology resides, then to answer the Q2 and furthermore describe the representative section, and finally to answer the Q3 and see in which liver segment the pathology is accurately present. Special attention to the localization of segment I, or the caudate lobe of the liver, is lastly illustrated. The Q1 identifies lobes; Q2 identifies sections, and Q3 identifies segments.

In our attempt to simplify the hepatic descriptive configuration, the liver will be simulated to a 2-floor, reversed flattened (L)-shaped building where the lower floor corresponds to the inferior segments and the upper floor represents the superior segments [Figure 1]. The separation of the two floors is formed by an imaginary transversal plane that bisects the liver into two unequal halves, which corresponds to the portal bifurcation. The liver is furthermore divided longitudinally by three planes which



**Figure 1:** Liver configuration shows as a reversed flattened L-shape. IVC: Inferior vena cava, RHV: Right hepatic vein, MHV: Middle hepatic vein, LHV: Left hepatic vein, PV: Portal vein, RPV: Right portal vein, LPV: Left portal vein

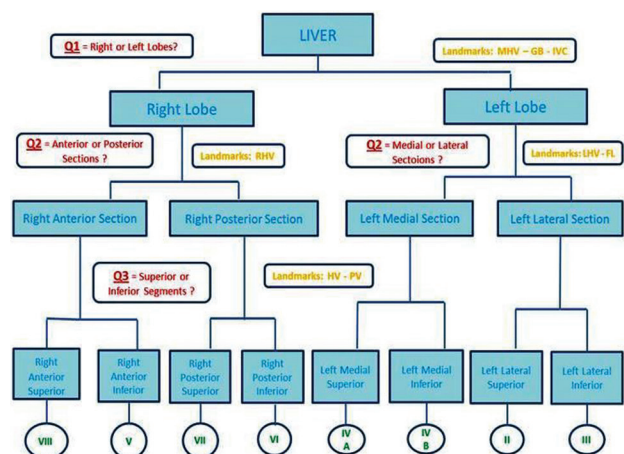
converge posteriorly into the inferior vena cava. These imaginary longitudinal planes correspond to the hepatic veins. The true division of the liver into right and left lobes overlap precisely over the middle hepatic vein superiorly and a plane that joins the medial border of the gall bladder to the lateral side of the inferior vena cava inferiorly that was initially defined by Cantlie.<sup>[4,5]</sup>

By referring to the “Triple-Q Algorithm” [Figure 2], three questions will direct the interpreter on a step-by-step fashion, from the complete integral liver to the smallest functional unit, which is the segment.

**Q1:** Regarding the liver pathology that you are trying to localize: Are you in the right or left lobe of the liver?

To be able to answer the Q1, the landmarks that truly divide the liver into two lobes and that are not completely visible on the outer surface of the liver are the following: The middle hepatic vein superiorly and the line that joins the medial wall of the gall bladder to the lateral border of the inferior vena cava inferiorly. This corresponds to the virtual line of Cantlie [Figure 3a].<sup>[4,5]</sup>

One should move the serial CAT scan cuts on a portovenous phase up and down repeatedly until the identification of the superior and inferior landmarks are made to be able to localize whether the liver pathology is located in the right or the left lobe. Intraoperatively, a superficial palpable pathology can be referred with ease to the lobe where it belongs, whereas a nonpalpable deep pathology will necessitate the use of intraoperative ultrasound (US) to define its relationship to the midline landmarks. The left hepatic vein is the other structure that divides the sections of the left lobe into medial and lateral sections and helps to identify the superior segments of this lobe.



**Figure 2:** The “triple-Q Algorithm”. IVC: Inferior vena cava. RHV: Right hepatic vein. MHV: Middle hepatic vein. LHV: Left hepatic vein, PV: Portal vein, GB: Gallbladder, FL: Falciform ligament, HV: Hepatic vein

**Q2-A:** If the pathology as referred in Q1 is in the right lobe; Is it located in the right anterior or right posterior sections?

Once pathology has been localized in the right liver lobe, the second step is to determine whether it is located anteriorly or posteriorly. The right lobe mass is divided by the right hepatic vein into an anterior section and a posterior section [Figure 3b]. By scrolling, the CAT scan cuts up and down; one can detect with ease the right hepatic vein with its course toward the lateral border of the inferior vena cava. There is unfortunately no definitive landmark that shows the separation of the two sections at the inferior level, and one should virtually project the plane of the right hepatic vein inferiorly until it reaches the inferior surface of the liver unless there is an aberrant right inferior hepatic vein that is present in approximately 28% of the cases<sup>[6]</sup> that can in this case separate the two sections inferiorly [Figure 3c]. Once again, deeper structures are localized intraoperatively with the help of US device.

**Q2-B:** If the pathology referred to in Q1 in the left lobe, are you located in the left medial section or the left lateral section?

The landmarks to differentiate both sections are the left hepatic vein superiorly and the round and falciform ligament inferiorly. Anything lateral to this plane corresponds to the left lateral section while medial structures will be in the left medial section.

**Q3:** The final question after localizing the above topography will be to locate a superior versus inferior segments, which corresponds to the smallest functional unit of the liver. To help answering this question, one should scroll again the CAT scan cuts craniocaudally. In case it visualizes any of the hepatic veins,

the segments seen herein are located superiorly, which will be either segment II, IV-A, VIII, or VII [Figure 4a]. Identifying the portal vein, portal bifurcation or any of its branches will entitle that the visualized segments are the inferior ones, which could be III, IV-B, V, or VI.<sup>[7]</sup>

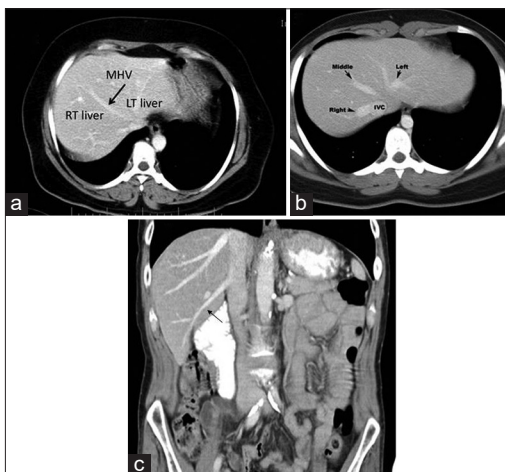
The last logical question is to define the location of the caudate lobe or segment I.

Segment I of the liver is situated on the posterosuperior surface of the liver, opposite the tenth and eleventh vertebrae. It is bounded on the left side by the ligament venous, remnant of the ductus venosus, bounded below by the porta hepatis, and on the right by the inferior vena cava. It looks backward, being nearly vertical in position, and extends obliquely and laterally to the undersurface of the right lobe of the liver.<sup>[8]</sup>

Segment I has an independent blood supply, and hence, a special location. It receives its inflow arterial and portal supply from simultaneous branches of the right and left hepatic vessels, and then drains the outflow blood through small branches directly to the anterior wall of the vena cava. The hepatic area located between the inferior vena cava posteriorly and the portal trunk anteriorly until it bifurcates, correspond to segment I, and any pathology located there belongs to this segment [Figure 4b]. Intraoperatively, the caudate lobe is located posteriorly, and to visualize it, one should open the lesser omentum through the pars flaccida to be able to see, palpate, or assess it by the intraoperative US probe.

Defining the hepatic segmentation was not an easy task to do, Healey and Schroy in the United States and Couinaud and Bismuth in France were the pioneers of such definition.<sup>[9-11]</sup> Unfortunately, each medical school has interpreted liver segmentations according to its understanding, leaving us with a vast diversity of literature – sometimes contradictory that describes the topographic anatomy of the liver.<sup>[8,9]</sup> This contradiction has urged the physicians and surgeons dealing with hepatobiliary pathology to call for an international meeting that was held in Brisbane in the year 2000 with subsequent adoption of a unified nomenclature that defines well the liver segmentation as well as the resectional surgical procedures performed on the liver.<sup>[12]</sup>

Standardizing the way to interpret and share medical information has several advantages. It will assure a common language between medical professionals and will reflect positively on the patient outcome and the level of care.<sup>[13]</sup> Describing accurately the location of liver pathology will help in defining the resectability of a neoplastic process and the magnitude of its extension.<sup>[14]</sup> Grading of liver injury is of significant importance when managing liver trauma as it will help in guiding the management principles and in tailoring the treatment modalities according to the progression of



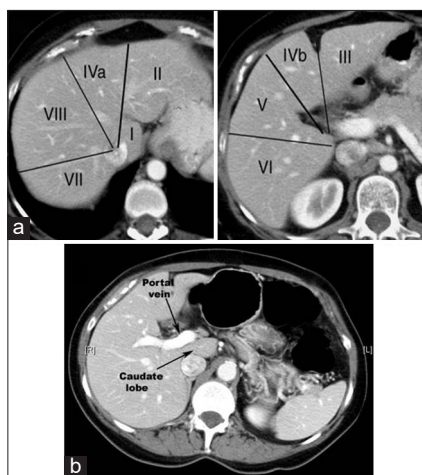
**Figure 3:** (a) True division of the liver through Cantlie's line passing through the middle hepatic vein (black arrow). (b) Hepatic veins trifurcation. (c) Accessory right inferior hepatic vein (black arrow). MHV: Middle hepatic vein, LT: Left, RT: Right, IVC: Inferior vena cava

the condition. The most famous liver injury grading system is disseminated internationally by the American Association for Surgery of Trauma, and it depends in its description of Grades IV and V on the magnitude of segmental liver injury.<sup>[15]</sup>

Till now, multiple international citations still mix the regional topography of the liver, leaving the health care provider confused in face of different literature. While Couinaud's classification<sup>[4,10]</sup> is a pure anatomical description, done *in vitro* on a flattened liver, the proposed description helps understand the topography of the liver segments intraoperatively and mainly when interpreting imaging modalities such as computed tomography scan and US, an interpretation that still confuses some radiologists and specialized surgeon. The algorithm is a simple approach to help acquiring a standardized way to describe the hepatic pathology. To prove the validity of the algorithm, it will be helpful to conduct a comparative study between two groups of junior physicians and evaluate the differences in the understanding of liver anatomy and the ability to localize a liver pathology accurately between a group who follow the Triple-Q Algorithm and a group who did not. It might be at that time possible to highlight the benefit, if proven scientifically, of the adoption of such algorithm when explaining and teaching the regional anatomical topography of the liver. We hope that it will facilitate the understanding of liver topography for the new medical graduate.

## CONCLUSION

Adopting the proposed algorithm will enable physicians to describe accurately the liver segmentations. This could be achieved after testing and validating this algorithm in prospective



**Figure 4:** (a) Superior segments (II, IVA, VIII, VII) shown on the left side and inferior segments (III, IVB, V, VI) on the right side. Note the appearance of a part of the caudate lobe (segment I) in the anteromedial pericaval area. (b) Location of the caudate lobe or segment I of the liver between the inferior vena cava and the portal vein

studies. This could have academic and clinical implications in the medical education and the patient care.

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## Conflicts of interest

There are no conflicts of interest.

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