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Isolated In-Situ Axial Hepatic Mal-Rotations: Implication on Laparoscopic; Surgical Anatomy and Practice

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Abstract

Introduction: Three dimensional anatomy and congenital anomalies are crucial determining the trocar positions and the optimal site view for any laparoscopic procedure. Such critical issue mandates preoperative diagnosis of topographic anatomical variations. Clinical reporting on congenital foregut anomalies does not include yet variation in liver rotation. This research is documenting such unrevealed anomaly and stressing on its implication in the field of contemporary laparoscopic surgery.

Materials and Methods: This is a case series study on congenital anomalies observed surgically and documented radiologically among 721 patients. Between January 2012 and October 2016, 721 surgical patients who were planned to have laparoscopic procedure for various abdominal pathology. All patients underwent; pre-operative abdominal computerized tomography. Each laparoscopic procedure started by hepatic exploration for congenital liver anomalies to verify the radiological findings.

Results: Total cases discovered to have congenital liver anomalies primarily by abdominal computarised tomography and verified by laparoscopy were 33 cases (4.56%). These cases are distributed as follows: variation in liver axial rotation 12 cases (1.66 %), ape's fissure 10 cases (1.38%), ectopic liver with accessory lobe 6 cases (0.83%) and fissure formation with anomalous lobe configuration 5 cases (0.69%). Presentation of two cases out of the twelve cases constituting mild and extreme degrees of mal-rotation.

Conclusion: Congenital liver anomalies constitute an important anomaly which is not extremely rare to face. Hepatic mal-rotations constituted one of the highest rates of liver anomalies in this study and yet not properly studied. This type of anomalies is neither recognized by anatomists nor clinicians. Abdominal computerized tomography scan is an essential recommendation prior to all upper abdominal laparoscopic procedures.

Keywords: Hepatic Axial Mal-Rotational; Three Dimensional Anatomy; Laparoscopic Surgery

List of abbreviations: Abdominal Computerized Tomography Scan (ACTS)

Introduction

In the era of endoscopic surgery; laparoscopic anatomy has proved crucial importance to surgeons. Laparoscopic anatomy adopts three dimensional identification of organs and their inter-relations. This concept differs from the traditional anatomy in adding the third dimension to the field of vision that endoscopic surgeons have to appreciate. Failure to apply the three dimensions' anatomy might be the cause for laparoscopic procedure complications, failures and even conversion to open ones. Laparoscopic anatomy texts tried to transfer the needed surgical anatomy to endoscopic surgeons but still there are knowledge defects to be full filled. That is why endoscopic surgeons continue reporting anatomical anomalies and alterations identified for the first time.

Congenital anomalies of the foregut are documented in detail for luminal organs. The axial rotation of the foregut is known to be 90 degrees clockwise in the horizontal plane i.e. from left to right side. Rotation of the liver as an anterior bud to the primitive stomach has to rotate by the same degree and direction to settle on the right side of the stomach upon completing full fetal age. The precise axonal definition and degree of rotation of the liver and dependent identification of the mal-rotation anomalies have been overlooked by clinical embryology or anatomy reviews as revealed by Skandalakis *et al.* [1]. Even more there are increasing reports on observations of hepatic mal-rotation by surgeons rather than anatomists [2-4].

In this study the author presents a case series of patients who are planned to have upper gastrointestinal laparoscopic procedure, were investigated for anatomical variations of the liver.

Material and Methods

This is a case series study screening surgical patients for congenital anomalies of the liver. All patients planned to have various upper gastrointestinal laparoscopic procedures were recruited in the study. Patients due for laparoscopic procedures were explored for congenital liver anomaly. If a congenital liver anomaly is positive, a documentary post-operative ACTS is achieved. Between January 2016 and October 2018, 721 patients were recruited in the study. None of patients were known to have hepatic anomaly before hospital admission.

Results

For all the 721 patients, upon laparoscopy, exploration of the liver is achieved routinely as the first step. The total number of cases discovered to have congenital liver anomalies was thirty three cases (4.6%) varying as follows: hepatic axial mal-rotation twelve patients (1.7%), ape's fissure ten patients (1.4%), ectopic and accessory lobe of the liver in six patients (0.8%) and fissure formation with anomalous lobe formation in five cases (0.7%). These six cases were documented by ACTS with both oral and intravenous contrasting. The ACTS views were reported routinely by a radiologist who knows nothing about the congenital liver anomaly. None of the positive cases for congenital liver anomaly were diagnosed by the radiologist reporting the case. The author used to interpret the ACTS views in comparison to the laparoscopic digital disc records and completes filing data for each case.

Patients' epidemiology & clinical data are shown in Table 1.

Variant	Value / Range	Mean ± SD
Total Study Case Number	721	
Age (Years)	22 - 56	31 ± 3.2
Gender; Male : Female	467 : 254 (1.8:1)	
Number of patients previously known to have congenital liver anomalies	0	
Age for 33 patients (Years)	31 - 47	38 ± 1.4
Gender; Male : Female	19 : 14	
Number of patients known to have congenital liver anomaly prior to this study	0	
Number of Congenital Malformations Detected (%) a. Hepatic mal-rotation b. Ape's Fissure c. Ectopic and accessory lobe of the liver d. Fissure formation with anomalous lobe configuration	 33 (4.6 %) 12 (1.7 %) 10 (1.4 %) 6 (0.8 %) 5 (0.7 %)	

Table 1: Patients' epidemiology & Clinical Data

Liver Mal-Rotation Case Sample Reporting

Out of 721 cases underwent this examination thirty three cases (4.6%) were found to have congenital variation in liver rotation with variable degrees. The author has selected two cases out of the twelve to demonstrate the anomaly; one moderate and another extreme extent hepatic in situ axial mal-rotation in comparison to the normal hepatic orientation. This rotational variation is

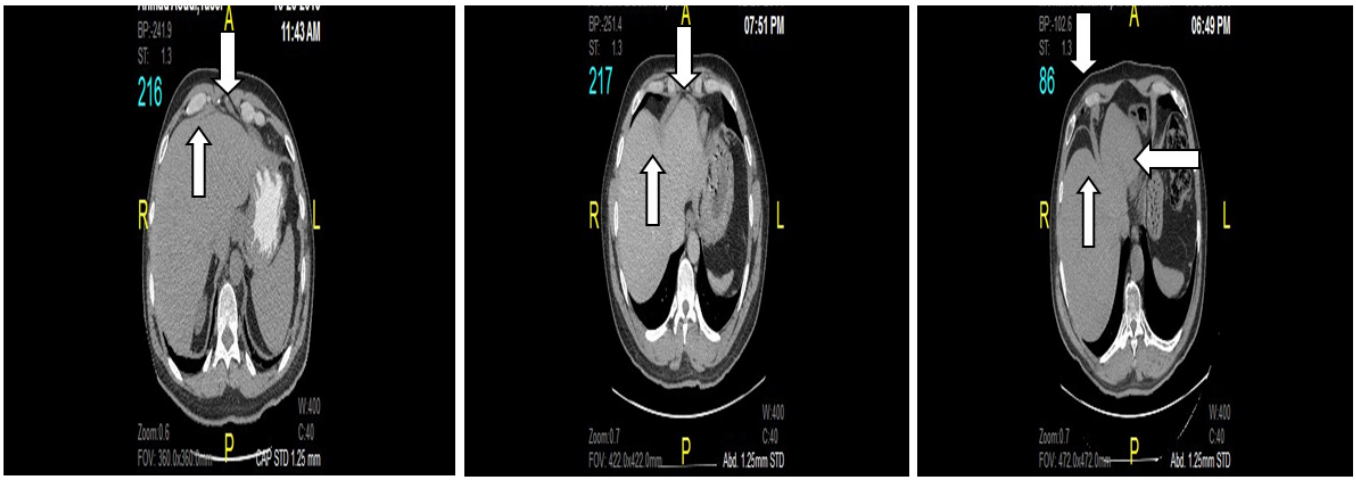


Figure 1, 2 and 3: Case 1; First Level: Level between Thoracic 12 to Lumber 1 Vertebrae
Progressive changes from Figure 1, 2, and 3 as the liver gradually regrets from the left half of the abdomen to lie mostly in the right half of the abdomen, the deviation of the round ligament attachment to the right near to anterior or mid axillary lines. The left lobe is rotated anticlockwise lying below the falciform ligament in the mid anterior region. The arrow in each figure points to the round ligament attachments being deviated more to the right from Figure 1, 2 and 3 by increasing the degree of liver mal-rotation as cases 2 and 3 are concerned. Splenic ptosis is increased from Figure 2 to Figure 3.

Figure 1,2 and 3: Normal liver; Case1, Lesser Liver Rotation; Case 2, Greater Liver Rotation

found to be anti-clockwise around the vertical axis of the liver (the vascular axis of the hepatic veins) which is considered the inferior vena cava in all the twelve cases discovered. Viscero-ptosis or caudal drop of the liver and the kidneys is noted in addition to the axial rotation. The relative relation of the stomach to liver was distorted from normal.

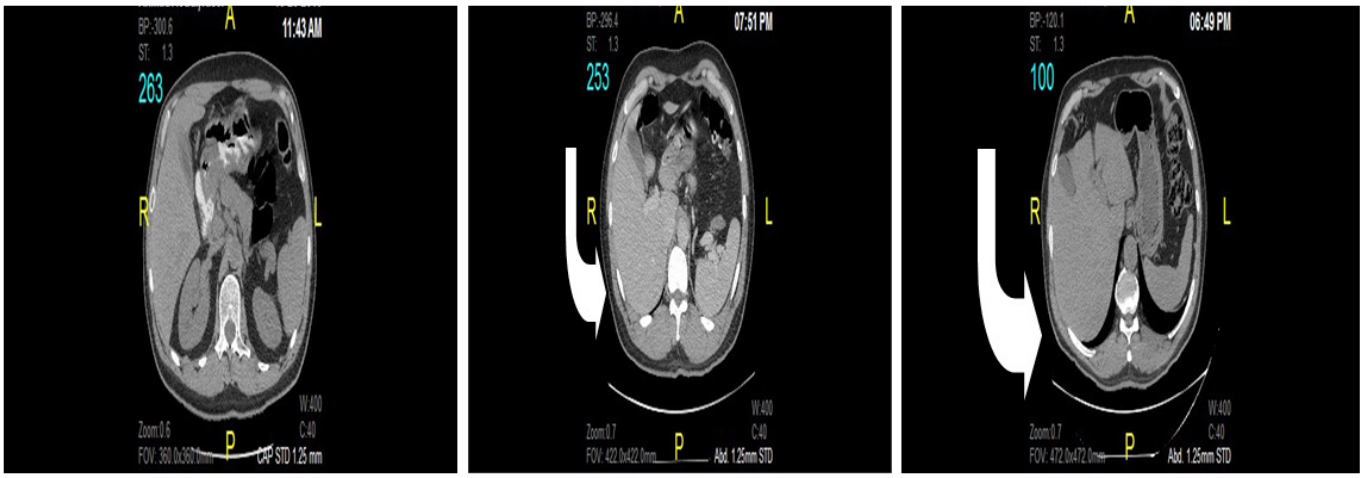
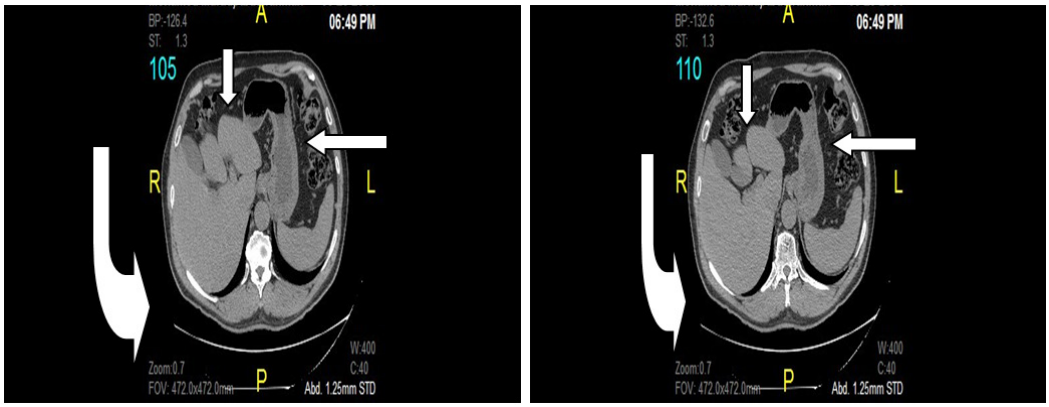


Figure 4, 5 and 6: Case 2; Second Level: Level Of Upper Lumber 1 Vertebra
Progressive rotation of the liver from Figures 4, 5 and 6 to the right manifested by converting the anterolateral surface to be posterolateral and the inferior surface to be anterior one. Notice ptosis of the liver and spleen down to levels of Lumber 1 Vertebra.

Figure 4,5 and 6: Normal liver; Case 1, Lesser Liver Rotation; Case 2, Greater Liver Rotation



The greater liver rotation case, left lobe is rotated to the right as if the liver is rotated upon itself in the vertical axis. The quadrate lobe is shifted to face between the anterior and mid axillary planes. The left hepatic lobe is reaching the level of gastric pylorus. As the liver is ptosed and pushed posteriorly, the kidneys are ptosed as well (still not viewed at this view level), below the level of Lumbar 1 Vertebra for the left kidney and Lumber 2 Vertebra for the right kidney. The stomach is deviating to the right to lie mostly in the midline in a linear sagittal plane with enlarged lieno-gastric space.

Figure 7 and 8: Case 2; Third & Fourth Levels Figures: Levels of Lower Lumbar 1 & Upper Lumbar 2 Vertebrae

Comparison of both cases with a normal case utilizing ACT views at equal spine levels is demonstrated in Figure 1,2,3,4,5 and 6. Demonstration of extra manifestations of liver rotational variation in case 2 is shown in Figure 7 and 8.

Case 1: Case of a male patient 26 years old, presented with clinical picture of acute appendicitis and underwent laparoscopic appendectomy. Case showed "Lesser Liver Mal-rotation" as demonstrated in ACTS (Figure 2 and 5).

Case 2: Case of a male patient 35 years old, presented with clinical picture of left inguinal indirect hernia that underwent laparoscopic trans-peritoneal inguinal hernioplasty. Case showed "Greater Liver Mal-Rotation" as demonstrated in ACTS (Figure 3,6,7 and 8).

Figure 1 and 4 are for a third study case showed to compare the mal-rotated liver to the normal liver ACTS views.

Interpreting the ACTS views revealed derangement in the hepatic position and relations to the surrounding organs specially the stomach and kidneys.

The following findings are detected:

First: Hepatic Mal-Rotation

Around the Vertical Axis: The liver is rotated in the vertical axis (Inferior Vena Cava) to the right side so that:

1. In the lesser liver mal-rotation case round ligament attachment to the liver is deviated to the right side in the anterior axillary plane. In the greater liver mal-rotation case both round ligament attachments to the liver and anterior abdominal wall are deviated to the right of the midline.
2. In the greater liver mal-rotation case the quadrate lobe is corresponding between the anterior and mid axillary planes.
3. In the greater liver mal-rotation case the left lobe is anteriorly displaced hardly crosses the mid line rather than reaching to the extreme left side. Obviously the tip of the left lobe is rotated and directed towards the porta hepatis.

In the horizontal axis (In Greater Liver Mal-Rotation Case)

1. The liver is ptosed leaving gap below the diaphragm.
2. The liver is rotated in the horizontal axis so that the inferior surface of the liver is rotated anteriorly. This unique situation exposes the gall bladder uncovered by any hepatic tissue along all its length facing the anterior abdominal wall i.e. the liver tissue lies postero-lateral to the gall bladder and the gall bladder lies directly posterior to the anterior abdominal wall.

Visceral Ptosis (In Greater Liver Mal-Rotation Case)

1. The liver is ptosed (positioned caudally) and gapped from the diaphragm.
2. The spleen is ptosed and gapped from the stomach.
3. The kidneys: Reduction of the retro-peritoneal retro-hepatic space had pushed both kidneys as follows:

a. The left kidney is ptosed and lies at level of low L1 to L3.
b. The right kidney is ptosed and lies at the level of L2 to L4.

Third: Deranged Mutual Relation between Liver and Stomach (in Greater Liver Mal-Rotation Case)

1. The hepatic left lobe is bending in the horizontal plane to lay in the mid-plane in relation to the gastric pylorus.
2. The stomach is shifted to the right side to lay in a linear sagittal plane, leaving a big lieno-gastric space.

Discussion

Hepatic mal-rotation anomaly is not that uncommon but rather unlooked for John Howell, the honorary surgeon at Cheltenham Central Hospital, UK, was the only author mentioned something about hepatic vertical axial rotation. Although this report was devoid of documentation but was the first to alert such anomaly [2].

Sato et al., have published a unique surgical study exploring hepatic anomalies laparoscopically, and estimated liver congenital anomalies as high as 19% of the sample studied [3].

Hepatic rotational variation was not identified literally among the anomalies they searched for. The study reported an intimate indicator to variations in hepatic rotation which is right deviation of the round ligament in addition of being highly inserted cephalad. This study did not mention any terminology about liver mal-rotation in spite of detecting some of its manifestations; that is deranged round ligament attachments. In addition the study did not document the anomalies revealed radiologically. The round ligament right deviation is one of the manifestations of axial liver rotation and to the right in the perpendicular plane and its high insertion is a manifestation of liver ptosis in the vertical plane that final makes the inferior liver surface faces the anterior abdominal wall and the right dome of the liver sinks posteriorly and inferiorly. This proves that this complex liver anomaly of liver rotational variation which was attributed to the hepatic round ligament displacement in Sato et al study, the author has rediscover as a three dimensional liver mal-rotation.

In the current study, the author has reviewed literature for references that study liver rotation variation in the fields of embryology, academic and clinical anatomy, radiology and surgery that revealed only a single post-partum case report by Zhong H. In his case report he documented liver rotation of almost 180 degrees in which the infero-posterior surface of the liver is facing anteriorly [4].

The appreciation of the three dimensional anatomy seems to be still not well applied to discover and describe the unrevealed congenital anomalies of the liver. Such problem is crucial and its clearance copes with the advances in laparoscopic surgery. Anomalous topography for sure hardens the practice of safe laparoscopic surgery and converts it hazardous. Identification of liver mal-rotation is of great importance to laparoscopic surgery working on the upper gastrointestinal and Hepatobiliary systems. Proper orientation with the topography of the field would define properly the locations of access ports and hence supplying the views of safety needed in laparoscopic procedures.

The routine recommendation of pre-laparoscopic surgery ultrasound examination is not sufficient and ACTS is needed for full orientation of the three dimensional organ anatomy. Starting laparoscopic procedures with an exploration of abdominal organs for organ anomalies would be late to discover the potential congenital anomaly existence.

Conclusion

Congenital anomalies concerning foregut mal-rotation do not include related liver anomalies. Liver three dimensional anatomy is not verified and so anomalies of such organ are still not investigated. Having such knowledge gap makes an anomalous liver been

overlooked by radiologists and surgeons as well. The importance of such subject in laparoscopic surgery working on the upper gastrointestinal and the hepato-biliary systems is extremely high. Identification of abdominal organs' topography prior to surgical procedure is mandatory to proper planning of the access ports and the field of vision needed during the procedure. Exploratory diagnostic laparoscopy as a start of the procedure provides a late assessment to the under minded anomaly. ACTS conforms an essential recommendation for all laparoscopic cases prior to surgery.

The claim that hepatic anomalies are extremely rare does not rely on a population survey that would strongly support such statement. The increasing number of case reporting this issue mandates a serious research combining anatomists, radiologists and surgeons who mostly face such issue during surgeries.

The current study is a humble trial on a narrow scale demonstrating the existence of variable degrees of axial liver mal-rotations that could be named "congenital axial liver mal-rotation". Anatomical research is invited to study the planes through which predefined hepatic landmarks are rotating in the fetal life. Anatomists have to define the normal three dimensional position of the liver to be considered by clinicians specially radiologists and surgeons. Moreover, the implications of such anomaly on the three dimensional configuration of the hepatic vascular and biliary trees would be tremendous. Definition of hepatic and body skeletal fixed points would save important demarcation regarding the degree and planes of rotational variations of the liver. Much effort on the level of post-mortum anatomical studies is needed to document such category of anomalies with all related organs' orientation as well. Critic is invited.

Statement of Disclosure

The author has no disclosures or conflicts of interest or financial ties to disclose related to this manuscript.

Statement for Publication

The author assures that no paper has been published or is under consideration for publication elsewhere.

Statement of Author Contribution

The submitted paper is "a single author research" taking all responsibility for every portion of the content; namely:

1. Conception and design of the work, analysis, interpretation of data for the work; AND
2. Drafting the work and revising it critically for important intellectual content; AND
3. Final approval of the version to be published; AND
4. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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