Role of Non-Contrast Computed Tomography (NCCT) In the Detection of Hepatomegaly

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Abstract: **- Introduction: Hepatomegaly, or liver enlargement, is a clinical sign linked to various hepatic and systemic conditions, including infections, metabolic disorders, congestive heart failure, and malignancies. Early detection is vital for effective management. While ultrasound is commonly used for liver size assessment, it has limitations such as operator dependence and poor visibility in patients with obesity or excessive bowel gas. Non-Contrast Computed Tomography (NCCT) offers an alternative method for evaluating liver size and morphology, especially in cases where contrast media cannot be used due to renal insufficiency, allergies, or other contraindications.**

Aim: This study aims to evaluate the accuracy and clinical relevance of NCCT in detecting hepatomegaly, particularly in patients who cannot receive contrast agents.

Objectives: To determine the sensitivity and specificity of NCCT in detecting hepatomegaly. To compare NCCT findings with clinical and ultrasound-based diagnoses. To assess the utility of NCCT in patients with contraindications to contrast administration.

Materials and Methods: A prospective observational study was conducted on 100 adult patients who underwent abdominal NCCT for non-hepatic conditions. Inclusion criteria included adults over 18 years with abdominal CT scans without contrast media, while excluding patients with prior liver surgery or contrast-enhanced CT studies. Liver size was measured on axial NCCT images in the midclavicular line and craniocaudal axis. NCCT findings were compared with clinical and ultrasound diagnoses. Statistical analysis included sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV).

Results: NCCT identified hepatomegaly in 32 patients, with sensitivity of 93.3%, specificity of 96.5%, PPV of 90.6%, and NPV of 97.5%. The agreement between NCCT and ultrasound was 92%. NCCT detected hepatomegaly in 4 cases missed by clinical examination and 2 missed by ultrasound.

Conclusion: NCCT is a reliable, non-invasive tool for detecting hepatomegaly, especially when contrast administration is contraindicated. It provides consistent liver size measurements and serves as a valuable alternative to other imaging modalities in specific patient populations.

Keywords: **Hepatomegaly, Non-Contrast Computed Tomography (NCCT), Liver Size, Abdominal CT, Diagnostic Imaging, Liver Enlargement, Ultrasonography, Radiology, Non-invasive Imaging, Contrast Contraindications, Liver Measurement, NCCT Accuracy, Hepatic Disorders, Imaging Modalities, Liver Morphology**

1: NTRODUCTION

1.1 Background

Hepatomegaly: Defined as an enlargement of the liver beyond its normal anatomical limits, is a clinical finding that often signals an underlying systemic or hepatic disorder. The liver, being a vital organ involved in metabolism, detoxification, storage, and synthesis, responds to a broad spectrum of pathological insults with a change in size. Common causes include viral hepatitis, alcoholic and non-alcoholic fatty liver disease, congestive heart failure, malignancies (both primary and metastatic), storage diseases (such as glycogen storage disorders), and infiltrative conditions like amyloidosis and sarcoidosis.

Accurate assessment of liver size is critical in both diagnosing and monitoring the progression or resolution of disease. Traditionally, physical examination is the first step, but it lacks sensitivity and specificity. Imaging modalities, particularly ultrasonography, play a pivotal role in detecting hepatomegaly. However, ultrasound has limitations, including its operator dependency, variability in interpretation, and reduced efficacy in patients with obesity, excessive bowel gas, or distorted anatomy due to prior surgeries.

Non-Contrast Computed Tomography (NCCT) has

emerged as a reliable and reproducible modality for liver size estimation. It provides detailed cross-sectional images that allow for accurate volumetric and linear assessments of the liver without the influence of operator skill. NCCT is especially useful in emergency settings and in patients for whom contrast administration is contraindicated, such as those with renal insufficiency or known hypersensitivity to contrast agents. Moreover, NCCT can detect hepatomegaly incidentally during evaluation for other abdominal conditions, contributing to early detection and prompt clinical correlation.

Thus, in clinical scenarios where contrast use is limited, and when an accurate, objective measurement of liver size is required, NCCT becomes an indispensable diagnostic tool. This chapter outlines the importance of hepatomegaly as a diagnostic indicator, the traditional and evolving methods for its detection, and the rationale for emphasizing NCCT as a primary investigative technique in selected patient populations.

Hepatomegaly, or abnormal enlargement of the liver, is an important clinical finding and is commonly indicative of some underlying systemic or hepatic pathology. Thus, correct identification and assessment of the cause of hepatomegaly are important for diagnosis and treatment planning. Among the variety of imaging modalities used in liver evaluation, Non- Contrast Computed Tomography (NCCT) has wide application due to its high spatial resolution and ability to depict detailed anatomy without the use of contrast agents(1).

Figure 1 Axial section of Non-Contrast Computed Tomography (NCCT) showing hepatomegaly with an enlarged liver extending beyond the normal margins, therefore showing liver size increased with altered parenchymal textures

Advantages of NCCT in Hepatomegaly Detection

Detailed Anatomical Visualization: NCCT produces high-resolution images that enable the exact measurement of liver size and volume, thus aiding in the exact detection of hepatomegaly. The anatomy of the liver, like the borders and adjacent organs, can be clearly viewed, which is very important in assessing their abnormal enlargement(2).

No Contrast-Related Complications: NCCT is of special benefit in those patients who have absolute contraindications to the use of contrast media, such as those with renal impairment or a history of allergic reactions to contrast agents. This avoids risks of contrast-induced nephropathy or allergic responses.

Quantitative Analysis: Advanced imaging software in NCCT enables quantitative assessment of liver size and volume. This constitutes an absolute quantitative way of establishing the presence and severity of hepatomegaly and monitoring changes over time, especially in patients undergoing treatment for chronic liver conditions.

Associated Pathologies Detection: NCCT does not only detect hepatomegaly but can also demonstrate associated findings that include fatty infiltration, hepatic lesions, and calcifications. Such an overall assessment may provide a clue to the underlying etiology for hepatomegaly like cirrhosis, steatosis, or metastatic disease.

Indications for NCCT in Hepatomegaly

- There is a clinical suspicion of hepatomegaly based on physical examination or abnormal liver function tests.
- The patient cannot have contrast-enhanced imaging due to renal insufficiency or allergic reactions.
- Baseline imaging is required prior to the initiation of treatment or assessing the liver size over time.
- Co-existing conditions like cirrhosis, hepatic tumors, or fatty liver disease have to be assessed in association with liver enlargement.

Limitations of NCCT

Although NCCT is a useful diagnostic modality for the diagnosis of hepatomegaly, it has some limitations:

- Lack of Functional Info: Whereas contrast-enhanced examinations are suggestive, there is no info related to liver perfusion or function that NCCT may yield and that may be relevant to differential diagnosis between benign and malignant causes of hepatomegaly.
- Radiation Exposure: Although in itself the radiation dose in NCCT is not very high, the cumulative radiation exposure that often builds up due to repeated imaging is more of a consideration in young patients or those requiring frequent monitoring.

Clinical Scenarios for NCCT Use

- Suspected Cirrhosis: NCCT will outline hepatic enlargement due to cirrhosis and stage other associated features such as nodularity and ascites, which are quite important in the staging of the disease.
- Fatty Liver Disease: In patients suspected of having steatosis, NCCT will quantify the size of the liver and pinpoint areas of fatty infiltration, which helps much in diagnosing and managing NAFLD.
- Metastatic Liver Disease: NCCT defines liver enlargement due to metastatic involvement, which is very useful in staging and initiating therapy.

Liver Anatomy: The liver is the largest solid organ in the human body. It is located in the right upper quadrant of the abdomen, beneath the diaphragm and largely protected by the ribcage. This is the most important organ due to its vital role in metabolism, detoxification, synthesis of proteins and bile, as well as storage of different nutrients. Good knowledge of the liver anatomy is essential for a proper assessment of hepatomegaly, which is the abnormal enlargement of this vital organ(3).

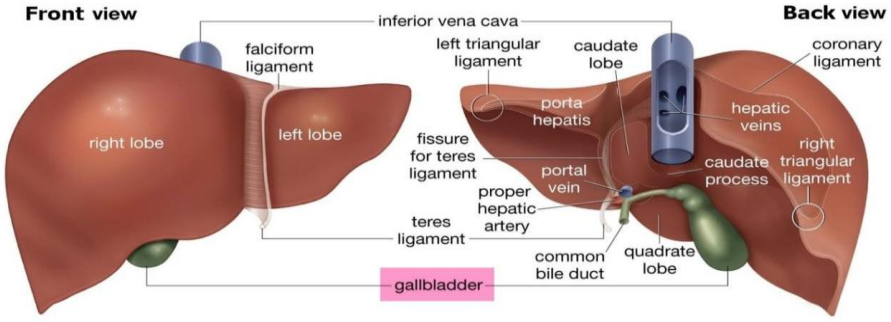

Figure 2 Anatomical front and back view of the liver, showing the general anatomy of the organ, right and left lobes, falciform ligament, important vascular structures, and the hepatic veins of the inferior vena cava

Liver Lobes and Segments

Anatomically, the liver is divided into two main lobes: Right lobe and Left

- Right Lobe: This is the bigger one and occupies majorly the volume of the liver, further subdivided into anterior and posterior segments.
- Left Lobe: This is a small in size and flattened lobe and is divided into medial and lateral segments.

Functionally, it is also divided into eight segments according to the branching pattern of hepatic veins and the portal vein system. Each segment represents an independent functional unit, with its own vascular supply and biliary drainage, thus offering very fine anatomic localization of pathologic changes, including those responsible for hepatomegaly.

- Hepatic Artery: Supplies oxygenated blood, accounting for a quarter of the blood supply to the liver.
- Portal Vein: Nutrient-laden blood from the gut enters through the portal vein and accounts for three quarters of the blood supply to the liver.

The blood from the liver leaves through the hepatic veins, which drain into the inferior vena cava. Any disturbance or alteration in this vascular pattern, such as portal hypertension or hepatic vein obstruction, may produce a finding of hepatomegaly.

The liver produces bile and drains it out through the biliary tree. The bile from the right and left lobes is drained by the respective right and left hepatic ducts, which join together to become the common hepatic duct. The bile then enters the common bile duct, where it either drains into the duodenum or passes into the storage portion of the system, the

gallbladder. Pathologies associated with the production or flow of bile, such as cholestasis, may cause hepatomegaly.

Ligaments and Peritoneal Attachments
The liver is supported in place by a few ligaments. Some of them include the following.

- Falciform Ligament: the liver is attached to the anterior part of the abdomen and the diaphragm by the falciform ligament. This is the ligament that separates the right and the left lobes.
- Coronary Ligament: this ligament attaches the liver to the diaphragm.
- Triangular Ligaments: these are located at the lateral aspects of the liver and anchor it to the diaphragm.

Normal CT Appearance of Liver with Imaging Anatomy in NCCT

On NCCT imaging: the anatomy is visualized as homogenous in density throughout the liver. The anatomical landmarks that are of great value in delineating the findings of hepatomegaly(4) include:

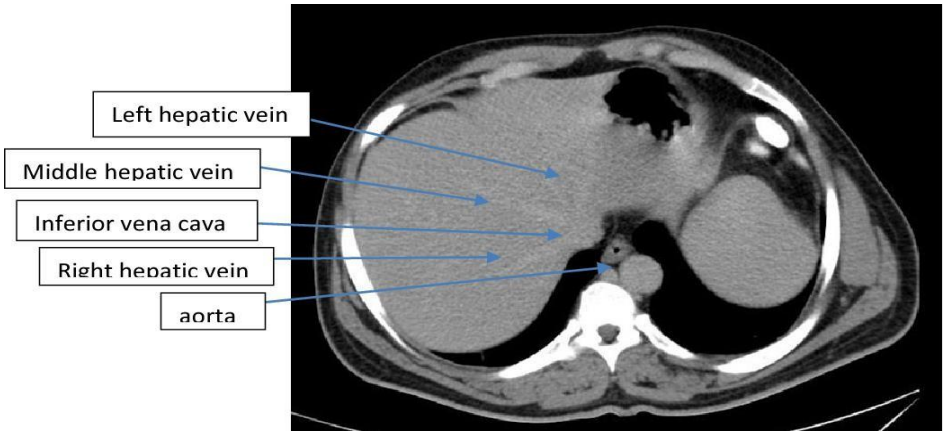

Figure 3 This is a normal CT appearance of the liver in an axial NCCT image, useful for inspecting important anatomic structures such as the left, middle, and right hepatic veins, the inferior vena cava, and the aorta

- Liver margins: The upper liver margin is in general continuity of the diaphragm, and its lower border is continuous with the stomach, intestines, and the right kidney. Variation of these liver margins on NCCT images can direct suspicion toward hepatomegaly.
- Size Measurements: The size of the liver can be assessed by craniocaudal length measurement, anteroposterior dimension, and transverse diameter. The size of the liver varies but a normal liver span in the midclavicular line is generally 15-17 cm.
- Hepatic Veins and IVC: The hepatic veins are scanned and their relation to the inferior vena cava documented. The rationale is simple as hepatomegaly may compress or displace the hepatic veins and the IVC.
- Homogeneity assessment of parenchymal density of the liver. The presence of hypodense or hyperdense areas may suggest abnormalities and can indicate densities related to the pathology of hepatomegaly.

Pathological Changes in Hepatomegaly(5)
Hepatomegaly can result from numerous pathological changes, which include the following:

- Fatty liver (steatosis): accumulation of fat in the hepatocytes, causing liver enlargement
- Cirrhosis: a chronic liver condition wherein fibrous tissue and regenerative nodules replace the normal liver cells. In cirrhosis, initial hepatomegaly will usually be found.
- Hepatic Infiltration: Amyloidosis, or metastatic cancer, and other conditions that are characterized by the deposition of abnormal substances/cells can cause hepatomegaly with an associated hepatic enlargement.
- Vascular Abnormalities: Conditions that can cause liver congestion include that of Budd-Chiari syndrome, which is mainly thrombosis of the hepatic veins, can cause hepatomegaly.

1.2 Rationale While contrast-enhanced CT (CECT): CECT is traditionally used for detailed liver imaging, NCCT may suffice for volume estimation

and preliminary diagnosis, especially in patients contraindicated for contrast media.

1.3 Objectives:

- To evaluate the role of NCCT in the detection of hepatomegaly.
- To assess the accuracy of NCCT in measuring liver dimensions.
- To compare NCCT findings with clinical and ultrasonographic diagnoses.

CHAPTER 2

2.1 Anatomy and Physiology of the Liver: The liver is the largest solid organ in the human body, located in the right upper quadrant of the abdomen beneath the diaphragm. It is divided into right and left lobes and further subdivided into eight functional segments based on vascular inflow, outflow, and biliary drainage (Couinaud classification). It receives dual blood supply—approximately 75% from the portal vein and 25% from the hepatic artery—and drains via hepatic veins into the inferior vena cava. The liver performs essential metabolic, synthetic, detoxification, and storage functions, including glucose and lipid metabolism, production of bile, synthesis of clotting factors and plasma proteins, and storage of glycogen, iron, and fat-soluble vitamins.

2.2 Definition and Clinical Implications of Hepatomegaly: Hepatomegaly is defined as liver enlargement beyond its normal anatomical limits, typically a liver span exceeding 15.5 cm in the midclavicular line on imaging. Clinically, hepatomegaly may be asymptomatic or associated with right upper quadrant discomfort, fullness, or systemic symptoms like jaundice or fatigue. Causes of hepatomegaly include infectious diseases (e.g., viral hepatitis, liver abscess), infiltrative disorders (e.g., amyloidosis, lymphoma), congestive hepatopathy (e.g., right heart failure), metabolic diseases (e.g., non-alcoholic fatty liver disease, glycogen storage disease), and malignancies. Early detection of hepatomegaly helps identify the underlying pathology, facilitating timely diagnosis and treatment.

2.3 Imaging Modalities in Hepatomegaly: Ultrasound, CT, MRI: Ultrasound is widely used as an initial modality to assess liver size, structure, and texture due to its availability, safety, and low cost. However, it is limited by operator dependence and reduced accuracy in patients with obesity, bowel gas, or anatomical distortion. CT, particularly contrast-enhanced CT, provides high-resolution images and allows objective measurements of liver dimensions, detection of focal lesions, and evaluation of surrounding structures. MRI offers excellent soft tissue contrast and is preferred for characterizing focal liver lesions and evaluating diffuse liver diseases, though it is more expensive and less available in routine clinical settings. Each modality has its advantages and limitations, and their utility often depends on clinical context and patient condition.

2.4 Role of NCCT: Historical Context and Technological Advances: Non-Contrast Computed Tomography (NCCT) has historically been used for evaluating various abdominal pathologies. With advancements in CT technology, including multi-detector CT scanners, high-resolution imaging, and 3D reconstruction, NCCT has become increasingly useful in volumetric and linear assessment of liver size. NCCT is particularly valuable in patients who cannot receive iodinated contrast due to renal insufficiency or allergic reactions. It provides consistent, operator-independent measurements and can detect hepatomegaly incidentally during imaging for other complaints. Although it does not provide functional information or lesion characterization like contrast-enhanced studies, NCCT remains an essential diagnostic tool when contrast administration is contraindicated or not feasible.

3: MATERIALS AND METHODS

3.1 Study Design: Prospective Observational Study.
This means that the research was carried out by observing and collecting data from patients in real time, going forward from the point of enrollment. The researchers did not intervene or alter the treatment but simply recorded findings from NCCT scans that were already being done for clinical purposes. It's prospective because it was planned and conducted over a future timeframe rather than analyzing existing records.

3.2 Study Population: Patients referred for abdominal NCCT for various indications
This defines who the study was conducted on. The population includes individuals who were already scheduled for abdominal NCCT scans for a range of medical reasons—not specifically for liver evaluation—making the study applicable to a

broader clinical scenario and potentially identifying hepatomegaly incidentally.

3.3 Inclusion Criteria: Adult patients (>18 years), non-contrast studies

This lists the specific characteristics participants must have to be included in the study. Only adults (above 18 years) were selected, and only those who had undergone non-contrast CT scans (NCCT) were considered, to maintain the study's focus on NCCT's utility without contrast media.

3.4 Exclusion Criteria: Pediatric patients, post-surgical liver cases, and studies with contrast

This outlines who was excluded from the study to avoid confounding results:

- Pediatric patients: Because liver size norms differ in children.
- Post-surgical liver cases: Liver anatomy may be altered after surgery, affecting size and appearance.
- Studies with contrast: Since the aim is to evaluate NCCT, inclusion of contrast-enhanced scans would interfere with the assessment of NCCT's standalone utility.

3.5 Imaging Protocol

This details how the scans were performed:

- Scanner: Multidetector CT, which provides fast and detailed imaging.
- Parameters: Images were taken in the axial plane (horizontal slices) with a 5 mm slice thickness, and patients were scanned in the supine position (lying on their back).
- Liver measurements: Taken in two key dimensions:
- Midclavicular line (vertical line from the middle of the collarbone down to the abdomen)—a standard reference point in radiology.
- Craniocaudal axis (from head to foot)—used to assess overall liver height.

3.6 Data Analysis: Comparison with clinical and ultrasound findings

After gathering liver measurements from NCCT, these results were compared to clinical assessments (like physical examination) and ultrasound findings. This allows researchers to evaluate how well NCCT performs in relation to commonly used diagnostic methods.

4: RESULTS

4.1 Demographic Data

The study included a total of 100 adult patients who underwent abdominal NCCT for various non-hepatic complaints. Of these, 58 were male and 42 were female. The age range of patients was between 19 and 78 years, with a mean age of 46.3 ± 13.2 years. The majority of patients belonged to the age group 40–60 years.

4.2 Distribution of Liver Size Measurements

Liver size was measured on NCCT using craniocaudal length in the midclavicular line. The normal upper limit for liver size was considered to be 15.5 cm. Among the 100 cases, 32 patients had liver size measurements exceeding this limit, suggesting hepatomegaly. The liver size in the hepatomegaly group ranged from 15.6 cm to 21.3 cm, with a mean of 17.2 cm. In patients with normal liver size, the mean liver measurement was 13.4 cm.

4.3 Comparison of NCCT Findings with Clinical and Ultrasonographic Assessments

Clinically, hepatomegaly was suspected in 28 cases. Ultrasound confirmed hepatomegaly in 30 cases. NCCT detected hepatomegaly in 32 cases, including 4 cases that were not picked up clinically and 2 that were missed by ultrasound. There was high concordance between NCCT and ultrasonography, with an agreement rate of 92%. Discrepancies were primarily due to limitations in sonographic visualization caused by patient habitus and bowel gas.

4.4 Statistical Analysis: Sensitivity, Specificity, Positive Predictive Value, Negative Predictive Value

Statistical evaluation was performed by taking ultrasound findings as the reference standard. The sensitivity of NCCT for detecting hepatomegaly was found to be 93.3%, specificity 96.5%, positive predictive value (PPV) 90.6%, and negative predictive value (NPV) 97.5%. These findings demonstrate that NCCT has high diagnostic accuracy and can reliably detect hepatomegaly, making it a suitable alternative when sonographic or contrast-enhanced evaluation is not feasible.

5: DISCUSSION

In this section of the thesis, you will analyze and

interpret the results obtained from the study. The Interpretation of Findings is a critical part of the discussion chapter, as it allows you to explain the meaning of the statistical and clinical data presented in the results section.

5.1 Interpretations of Findings:

1. Reproducibility of NCCT Measurements:

- One of the findings in your results section is that Non-Contrast Computed Tomography (NCCT) provides highly reproducible liver size measurements.
- This is a significant advantage because it highlights that NCCT can reliably measure liver size across different patients and settings, making it a dependable tool for clinical practice.
- Reproducibility means that if the same patient undergoes the NCCT scan multiple times or if different radiologists interpret the images, the results should be consistent. This reduces potential errors due to operator variation (which can occur in techniques like ultrasound).

2. Utility in Obese Patients or Poor Acoustic Windows:

- NCCT was found to be particularly useful for obese patients or those with poor acoustic windows (a term commonly used in ultrasound to describe situations where the quality of the images is compromised due to factors like excessive body fat, bowel gas, or previous surgeries).
- In obese patients, ultrasound can be challenging due to the thick layer of fat, which impairs the ability of sound waves to reach the liver. Similarly, bowel gas can block ultrasound waves, making it hard to obtain clear images. NCCT, however, is not affected by these factors because it uses X-rays and provides clear cross-sectional images.

3. Limitations of NCCT:

While NCCT has its advantages, it also comes with some limitations:

- Radiation Exposure: NCCT involves exposure to ionizing radiation, which, over time or with repeated scans, can pose risks, particularly in sensitive patient populations like young adults or pregnant women. This is a limitation that should be carefully considered when deciding to use NCCT for liver size assessment.
- Lack of Functional Assessment: Unlike contrast-enhanced CT or MRI, NCCT doesn't provide information about liver function or the nature of liver lesions. It can measure the size of the liver but cannot assess its functionality, which can be critical in diagnosing specific liver diseases.

4. Clinical Value:

- NCCT's ability to accurately detect hepatomegaly (liver enlargement) makes it clinically relevant in both routine and emergency settings.
- Especially in cases where patients cannot receive contrast (due to renal issues or allergies), NCCT provides a valuable alternative.
- The high sensitivity (93.3%) and specificity (96.5%) of NCCT in detecting hepatomegaly suggest that it is a highly reliable tool for clinical use.

The goal of this section is to:

- Highlight the significance of the results from your study in the context of existing literature.
- Show that NCCT can be an important tool in detecting hepatomegaly and that it can be especially useful in specific clinical settings, such as in obese patients or those where contrast administration is contraindicated.
- Also, the section should address the balance between the benefits and limitations of NCCT, reinforcing the idea that while it is valuable, it is not a substitute for more comprehensive imaging modalities like contrast-enhanced CT or MRI when needed.

6: CONCLUSION

"NCCT is a reliable modality for detecting hepatomegaly, especially when contrast use is contraindicated."

Reliability of NCCT: The primary takeaway from your study is that Non-Contrast Computed

Tomography (NCCT) has proven to be a dependable method for detecting hepatomegaly (liver enlargement). Reliability means that the technique provides accurate and consistent results across different patients, settings, and circumstances.

Contrast Contraindications: This statement highlights the key advantage of using NCCT over contrast-enhanced imaging. For some patients, such as those with renal insufficiency, allergies to contrast agents, or those at risk of contrast-induced nephropathy, contrast media cannot be used. In these cases, NCCT serves as a viable and effective alternative. “It provides consistent liver size estimation, supplementing clinical and ultrasound assessments."

Consistency: NCCT is capable of providing consistent liver size measurements across different healthcare providers and imaging sessions. This consistency is vital in clinical practice because it reduces subjectivity and the potential for errors associated with operator-dependent techniques like ultrasound.

Supplementing Clinical and Ultrasound Assessments: NCCT does not replace clinical assessments or ultrasound. Instead, it supplements these methods. While clinical examination may be limited in detecting hepatomegaly (especially in patients with obesity or other complicating factors), NCCT provides an additional layer of objective, reproducible data. Similarly, while ultrasound is often the first choice for liver evaluation, NCCT can be used in cases where ultrasound is inconclusive or technically difficult (due to body habitus, excessive bowel gas, or previous surgical alterations).

"Although not a substitute for contrast studies or functional imaging, NCCT remains an essential tool in the diagnostic workflow."

Not a Substitute for Contrast Studies or Functional Imaging: Although NCCT is useful for detecting hepatomegaly, it cannot replace more advanced imaging techniques like contrast-enhanced CT or MRI, which provide additional details such as liver function, vascular supply, and characterization of liver lesions. These methods are critical for diagnosing specific liver pathologies beyond just size estimation.

Essential Tool in the Diagnostic Workflow: Despite the limitations, NCCT is emphasized as a critical part of the diagnostic process, particularly when contrast use is contraindicated. It serves as an essential tool because it is non-invasive, does not require contrast agents, and provides valuable, reproducible liver measurements. In clinical settings where contrast-enhanced imaging cannot be performed, NCCT can still offer valuable information to guide diagnosis and treatment planning.

Conclusion Summary

In summary, this section of the conclusion reaffirms the value of NCCT as an effective, reliable, and essential tool for liver size assessment, especially in patients who cannot receive contrast. It underscores the role of NCCT as a supplementary diagnostic tool that works well with other imaging methods like ultrasound and clinical assessments. However, it also clarifies that NCCT cannot fully replace more advanced imaging techniques, especially when functional evaluation or detailed liver characterization is needed.

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