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Original Article

Anatomy Section

Prevalence of Hepatic Artery Variations on CT Using Michel and Hiatt Classification: A Retrospective Observational Study

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ABSTRACT

Introduction: The liver, a major abdominal organ, receives a dual blood supply: the portal venous system (70-80%) and the systemic arterial circulation (20-30%). The abdominal aorta supplies the gastrointestinal tract through three major branches: the coeliac axis, the superior mesenteric artery, and the inferior mesenteric artery. However, anomalies during embryogenesis may result in a wide diversity of anatomical variants. Regional data using modern Multidetector Computed Tomography (MDCT) are limited, particularly in the Indian population.

Aim: To determine the prevalence of anatomical variations of the common hepatic artery, right hepatic artery, and left hepatic artery in a South Indian cohort using Computed Tomography (CT) imaging.

Materials and Methods: The present retrospective observational study was conducted in the Department of Anatomy, PSG Hospitals, Peelamedu, Coimbatore, Tamil Nadu, India, from January 2023 to December 2023. The study population comprised patients who underwent CT whole abdomen scans for various indications during the study period. The primary outcome was to determine the prevalence and patterns of hepatic arterial anatomical variations as visualised on MDCT whole abdomen scans using Michel's and Hiatt's classifications. Data were analysed using descriptive statistics. Variations in hepatic artery anatomy were expressed as frequencies and percentages, and the results were presented in tabular form.

Results: A total of 1,089 CT abdomen reports yielded 1,094 observations according to Michel's classification and 1,093 observations according to Hiatt's classification, due to the presence of more than one variation per individual in some cases. Of the 1,094 observations classified using Michel's system, 717 (65.54%) demonstrated normal arterial anatomy, while 377 (34.46%) showed variations (Michel types II-X or Hiatt types II-VI and unclassified variants).

Conclusion: The present retrospective analysis highlights the presence of hepatic arterial variations in a significant proportion of the cohort, underscoring the importance of careful preoperative radiological evaluation to support accurate diagnosis, surgical planning, and the prevention of iatrogenic complications during interventional procedures.

Keywords: Accessory hepatic artery, Coeliac axis, Computed tomography, Inferior mesenteric artery, Replaced hepatic artery, Superior mesenteric artery

INTRODUCTION

The liver receives approximately 20-30% of its oxygen-rich blood supply from the hepatic artery, which constitutes a vital component of the hepatic vascular system [1]. Under normal developmental conditions, the common hepatic artery arises from the coeliac trunk at the level of the lower border of the T12 vertebra. It continues as the proper hepatic artery after giving rise to the gastroduodenal artery and proceeds toward the porta hepatis. The proper hepatic artery typically follows a curved course adjacent to the portal vein and divides into the right and left hepatic arteries, supplying the respective lobes of the liver. However, numerous anatomical variations may occur due to anomalies in embryological development [2]. These anatomical variations have been extensively documented and classified using systems such as Michel's classification (10 types) and Hiatt's classification (6 types) [Table/Fig-1] [3,4].

Knowledge of hepatic arterial anatomy is crucial for accurate diagnosis and planning of hepatobiliary surgeries, liver transplantation, Whipple's procedure (pancreatic head resection), and for avoiding iatrogenic complications during donor procedures, transarterial therapies such as hepatic chemoembolisation, and other endovascular interventions, including chemoinfusion pump placement [5,6]. Misidentification of variant arteries during surgery may result in inadvertent ligation, potentially leading to hepatic ischaemia or necrosis. Therefore, precise understanding of hepatic arterial architecture is of paramount importance in clinical practice.

Variation	Michel's classification	Hiatt classification
Normal anatomy	Type I	Type I
Replaced LHA arising from LGA	Type II	Type II
Replaced RHA arising from SMA	Type III	Type III
Replaced LHA and RHA	Type IV	Type IV
Accessory LHA from LGA	Type V	Type II
Accessory RHA from SMA	Type VI	Type III
Accessory RHA and LHA	Type VII	Type IV
Accessory LHA and replaced RHA	Type VIII	Type IV
CHA from SMA	Type IX	Type V
replaced CHA from LGA	Type X	-
CHA from aorta	-	Type VI

[Table/Fig-1]: Michel and Hiatt classification of hepatic artery anatomy [3,4].

The anatomy of the hepatic artery can be evaluated using contrast-enhanced CT (CECT) of the abdomen or CT angiography. MDCT angiography allows accurate and detailed visualisation of hepatic vascular anatomy [2]. The presence of arterial variations may necessitate modifications in surgical techniques, and the absence of appropriate preoperative imaging can increase the risk of complications [6,7].

Global studies have reported the prevalence of hepatic arterial variants to range between 20% and 50% [2]. Despite the clinical significance of these variations, there remains a paucity of recent large-scale studies utilising modern MDCT technology, particularly within the South Indian population. This study aims to address this gap by analysing a contemporary cohort of patients undergoing abdominal CT imaging at a tertiary care centre in South India.

MATERIALS AND METHODS

The present retrospective observational study was conducted in the Department of Anatomy, PSG Hospitals, Peelamedu, Coimbatore, Tamil Nadu, India, from January 2023 to December 2023. As the present study was a retrospective study, informed consent was not obtained, and a consent waiver was approved by the Institutional Human Ethics Committee (IHEC Approval Number: PSG/IHEC/2023/22/252).

Inclusion and Exclusion criteria: All radiographic images of patients who underwent CT whole abdomen scans with adequate arterial phase imaging, irrespective of age and sex, were included. Images with inadequate quality, history of previous hepatic or major abdominal surgery, and those with liver masses obscuring vascular anatomy were excluded.

Study Procedure

The study population comprised patients who underwent CT whole abdomen scans for various indications at the study institution during the specified period. A total of 1,089 patient records were initially identified. The origin, course, and branching patterns of the common hepatic artery and its branches were manually analysed according to Michel's and Hiatt's classifications [3,4].

Relevant images were retrieved from the hospital Picture Archiving and Communication System (PACS). All scans were independently reviewed by two physicians, and discrepancies were resolved by a senior radiologist.

STATISTICAL ANALYSIS

Data obtained from MDCT images and patient records were entered into a structured database and analysed using R software version 4.3.1. Categorical variables, including hepatic artery anatomical types and variants, were expressed as frequencies and percentages. Continuous variables, where applicable, were summarised using mean and standard deviation.

RESULTS

The present study evaluated the normal anatomy and variations in the origin, course, and branching patterns of the hepatic artery in a cohort of 1,089 patients aged between 5 and 93 years (mean age: 52±18 years). The cohort included 640 males and 449 females.

Among the samples analysed, 717 cases (65.84%) demonstrated normal Michel Type I anatomy [Table/Fig-2]. Variations in hepatic arterial origin and branching were observed in 372 patients (34.16%), of whom 151 (40.59%) were women and 221 (59.41%) were men. A total of 1,094 observations were classified according to Michel's classification, with 5 observations (0.46%) showing more than one variation in the same individual, hence using Michel's system 377 (34.46%) showed variations. The most common variant was Michel Type V, followed by Type III, observed in 97 (8.9%) and 88 (8%) cases, respectively. The least prevalent variant was Michel Type X, identified in one case (0.1%) [Table/Fig-2].

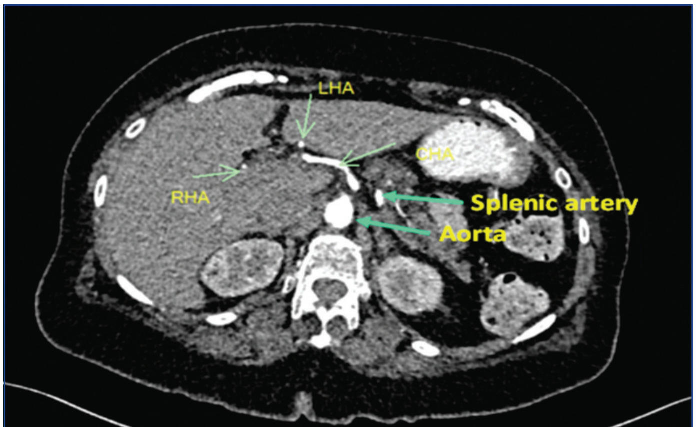
According to Hiatt's classification, 1,093 observations were analysed [Table/Fig-3], of which 717 (65.6%) exhibited normal anatomy [Table/Fig-4]. The most frequent variant was Hiatt Type II [Table/Fig-5], with a prevalence of 162 (14.8%), followed by Type III [Table/Fig-6] in 129 cases (11.8%). Hiatt Types V [Table/Fig-7] and VI [Table/Fig-8] were less commonly observed. Unclassified variants are shown in [Table/Fig-9].

Type	Michel classification	Number of variations observed in male (N=644)	Number of variations in female (N=450)	Total observations (N=1094)
I	Normal anatomy	420 (65.2%)	297 (66.0%)	717 (65.5%)
II	Replaced LHA arising from LGA	29 (4.5%)	35 (7.8%)	64 (5.9%)
III	Replaced RHA arising from SMA	54 (8.4%)	34 (7.6%)	88 (8.0%)
IV	Replaced LHA and RHA	9 (1.4%)	7 (1.6%)	16 (1.5%)
V	Accessory LHA from LGA	58 (9.0%)	39 (8.7%)	97 (8.9%)
VI	Accessory RHA from SMA	20 (3.1%)	10 (2.2%)	30 (2.7%)
VII	Accessory RHA and LHA	4 (0.6%)	4 (0.9%)	8 (0.7%)
VIII	Accessory RHA and replaced LHA or accessory LHA and replaced RHA	7 (1.1%)	9 (2.0%)	16 (1.5%)
IX	replaced CHA from SMA	23 (3.6%)	7 (1.6%)	30 (2.7%)
X	replaced CHA from LGA	1 (0.2%)	0 (0%)	1 (0.1%)
Unclassified	Unclassified	19 (3.0%)	8 (1.8%)	27 (2.5%)

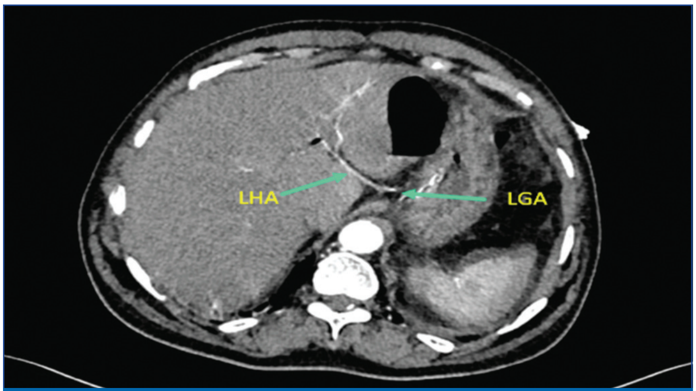
[Table/Fig-2]: Michel classification of hepatic artery anatomical variations categorised according to sex.
RHA: Right hepatic artery; LHA: Left hepatic artery; CHA: Common hepatic artery; SMA: Superior mesenteric artery

Type	Hiatt classification	Number of variations in male (no. of observations= 643)	Number of variations in female (no. of observations= 450)	Total observations (n=1093)
I	Normal	420 (65.3%)	297 (66%)	717 (65.6%)
II	Replaced or accessory LHA	87 (13.5%)	75 (16.7%)	162 (14.8%)
III	Replaced or accessory RHA	83 (12.9%)	46 (10.2%)	129 (11.8%)
IV	Replaced or accessory LHA+ replaced or accessory RHA	25 (3.9%)	24 (5.3%)	49 (4.5%)
V	CHA from SMA	23 (3.6%)	7 (1.6%)	30 (2.7%)
VI	CHA from aorta	4 (0.6%)	1 (0.2%)	5 (0.5%)
Unclassified		1 (0.2%)	0	1 (0.1%)

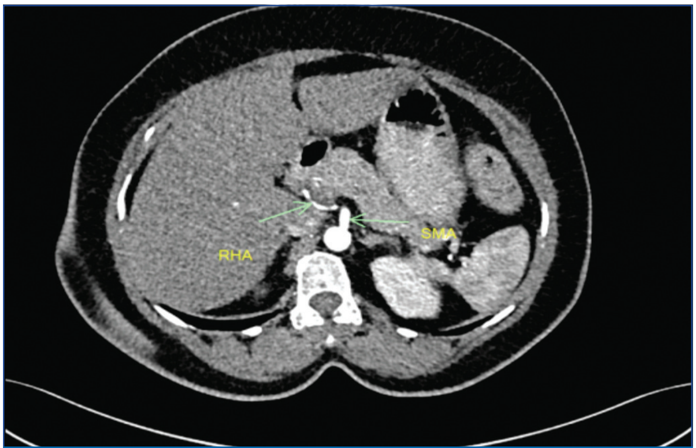
[Table/Fig-3]: Hiatt classification of hepatic artery anatomical variations categorised according to sex.



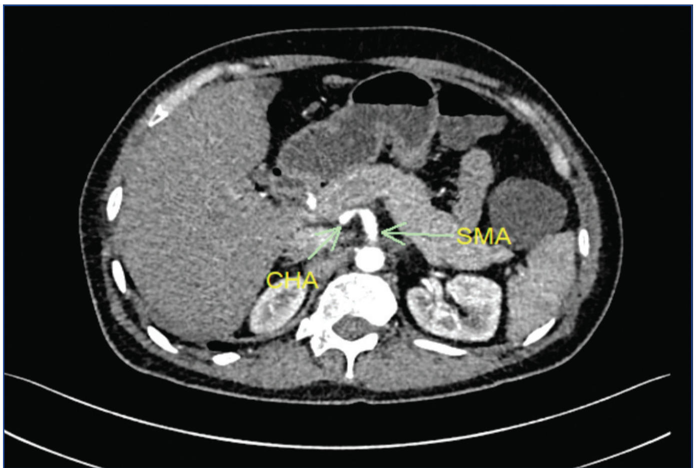
[Table/Fig-4]: Type-I HIATT's (Normal Anatomy)- Origin of Right Hepatic artery (RHA) and Left Hepatic Artery (LHA) from Common Hepatic Artery (CHA), terminal branch of Celiac axis of Aorta.



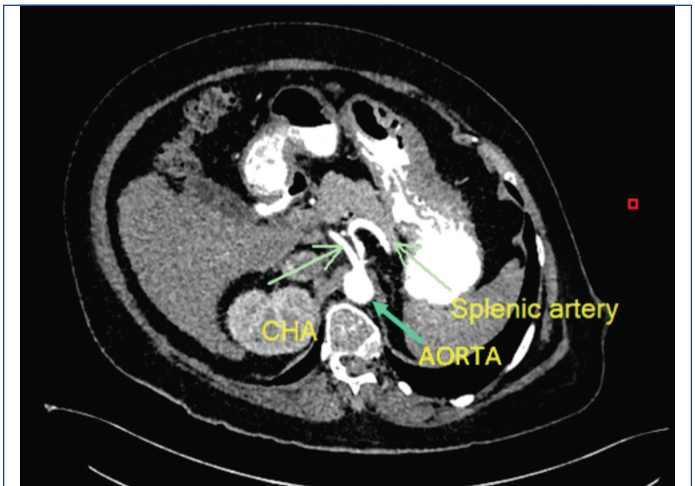
[Table/Fig-5]: Type-II HIATT's- Replaced Left Hepatic artery (LHA) from Left Gastric Artery (LGA).



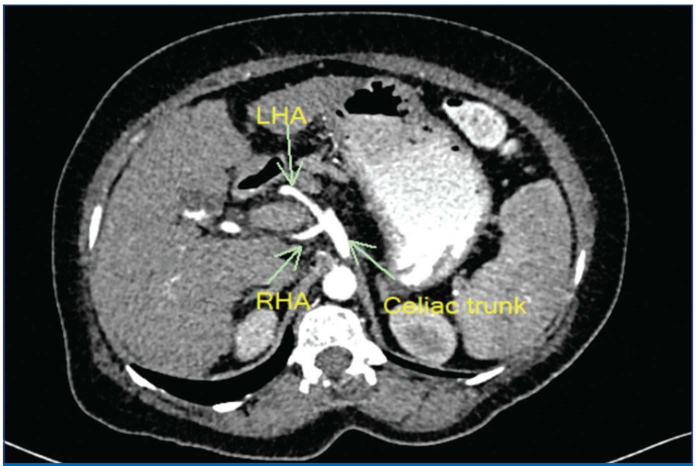
[Table/Fig-6]: Type-III HIATT's- Accessory Right Hepatic Artery (RHA) from Superior Mesenteric Artery (SMA).



[Table/Fig-7]: Type-V HIATT's- Common Hepatic Artery (CHA) from Superior Mesenteric Artery (SMA).



[Table/Fig-8]: Type-VI HIATT's- Common Hepatic Artery (CHA) from aorta.



[Table/Fig-9]: Unclassified- Trifurcation of coeliac trunk into Right Hepatic Artery (RHA), Left Hepatic Artery (LHA) and splenic artery.

DISCUSSION

The finding of 65.5% normal hepatic arterial anatomy (Michel Type I) in the present study aligns with previously reported prevalence rates, typically ranging between 65% and 80%. Choi TW et al., reported normal anatomy in 72.59% of cases, while Ognjanović N et al., reported 63.9% [8,9]. The slightly higher prevalence of variations in our cohort compared to some Western populations, such as that reported by Gkaragkounis A et al., (72.89% normal anatomy), may reflect regional or population-specific differences, underscoring the importance of local anatomical data [10].

Gkaragkounis A et al., reported Michel Types II-X variations in 22.24% of cases, with 4.87% remaining unclassified [10]. In contrast, our study identified Types II-X in 32% of observations, with 2.5% unclassified. While several studies have reported Michel Type III as the most common variant-5.63% in Fonseca-Neto OCLD et al., and 15.16% in Sureka B et al., [6,11] the present study found Michel Type V (8.9%) to be the most frequent, followed by Type III (8%).

Most published studies, including those by Ferrari R et al., and Araujo Neto SA et al., reported no occurrence of Michel Type X variants [12,13]. However, the present study identified this rare variant in one case (0.1%) [Table/Fig-10] [2,5,7-9,13,14].

Studies	Normal anatomy prevalence	Prevalence of variation	Most common variation and its prevalence	Place of study	Sample size
The present study	65.5	34.5	Accessory LHA from LGA (8.9%)	Tamil nadu, India	1089
Ognjanović N et al., [9]	63.9%	36.1%	Replaced RHA from SMA (9.6%)	Serbia	150
Thangarajah A and Parthasarathy R [14]	57%	43%	Accessory LHA from LGA (11%)	Tamil Nadu, India	200
Ugurel MS et al., [2]	52%	48%	Replaced RHA from SMA (17%)	Turkey	100
Choi TW et al., [8]	72.59%	27.1%	Replaced or aberrant LHA (16.32%)	South Korea	5625
Koops A et al., [5]	79.1%	20.9%	Accessory or aberrant RHA (11.9%)	Germany	604
Farghadani M et al., [7]	63.9%	36.1%	RHA from SMA (6.9%)	Iran	607
Araujo Neto SA et al., [13]	78.3	21.7	RHA from SMA (8.3%)	Brazil	60

[Table/Fig-10]: Comparison between various studies showing prevalence of variation in hepatic artery anatomy [2,5,7-9,13,14].

The Hiatt classification is particularly valuable in surgical planning, as it groups variants affecting specific hepatic lobes. The high prevalence of left hepatic artery variations (Hiatt Type II) observed in this study is clinically significant, especially during gastric and pancreatic surgeries where the left gastric artery and its branches are frequently dissected [6].

With the increasing frequency of invasive hepatic and hepatobiliary procedures, comprehensive knowledge of hepatic arterial variations and their preoperative identification is essential. Variants such as replaced or accessory hepatic arteries are particularly susceptible to injury during liver transplantation, pancreaticoduodenectomy, gastrectomy, and transarterial interventions, potentially leading to hepatic ischaemia or biliary complications. The high prevalence of left hepatic artery variations observed underscores the importance of careful assessment of the left gastric artery during upper gastrointestinal surgeries. Routine preoperative MDCT angiography is therefore crucial for minimising complications, optimising surgical planning, and improving patient outcomes, particularly in populations exhibiting region-specific anatomical patterns.

Limitation(s)

The primary limitation of the present study was its retrospective design. Additional limitations included interobserver variability, the single-centre nature of the data, and exclusion of poor-quality images, which may have introduced selection bias.

CONCLUSION(S)

The present study confirms that a substantial proportion of patients exhibit hepatic arterial variations consistent with Michel's and Hiatt's classifications, emphasising the importance of routine preoperative imaging in hepatobiliary surgery. A thorough understanding of these vascular variants is essential for surgeons and interventional radiologists to anticipate and prevent iatrogenic injuries during complex procedures such as liver transplantation, Whipple's surgery, and oncological interventions.

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REFERENCES

[1] Kan Z, Madoff DC. Liver anatomy: microcirculation of the liver. Semin Intervent Radiol. 2008;25(2):77-85. Doi: 10.1055/s-2008-1076685.

[2] Ugurel MS, Battal B, Bozlar U, Nural MS, Tasar M, Ors F, et al. Anatomical variations of hepatic arterial system, coeliac trunk and renal arteries: an analysis with multidetector CT angiography. Br J Radiol. 2010;83(992):661-67. Doi: 10.1259/bjr/21236482.

[3] Michels NA. Blood supply and anatomy of the upper abdominal organs: with a descriptive atlas. Philadelphia: J. B. Lippincott Company; 1955. 581 p.

[4] Hiatt JR, Gabbay J, Busuttil RW. Surgical anatomy of the hepatic arteries in 1000 cases. Ann Surg. 1994;220(1):50-52. Doi: 10.1097/00000658-199407000-00008.

[5] Koops A, Wojciechowski B, Broering DC, Adam G, Krupski-Berdien G. Anatomic variations of the hepatic arteries in 604 selective celiac and superior mesenteric angiographies. Surg Radiol Anat. 2004;26(3):239-44.

[6] Sureka B, Mittal MK, Mittal A, Sinha M, Bhambri NK, Thukral BB. Variations of celiac axis, common hepatic artery and its branches in 600 patients. Indian J Radiol Imaging. 2013;23(3):223-33. Doi: 10.4103/0971-3026.120273.

[7] Farghadani M, Momeni M, Hekmatnia A, Momeni F, Baradaran Mahdavi MM. Anatomical variation of celiac axis, superior mesenteric artery, and hepatic artery: Evaluation with multidetector computed tomography angiography. J Res Med Sci. 2016;21:129. Doi: 10.4103/1735-1995.196611.

[8] Choi TW, Chung JW, Kim HC, Lee M, Choi JW, Jae HJ, et al. Anatomic Variations of the Hepatic Artery in 5625 Patients. Radiol Cardiothorac Imaging. 2021;3(4):e210007. Doi: 10.1148/ryct.2021210007.

[9] Ognjanović N, Jeremić D, Živanović-Mačužić I, Sazdanović M, Sazdanović P, Tanasković I, et al. MDCT angiography of anatomical variations of the celiac trunk and superior mesenteric artery. Arch Biol Sci. 2014;66:233-40.

[10] Gkaragkounis A, Fanariotis M, Tepetes K, Fezoulidis I, Vassiou K. Celiac trunk and hepatic arteries: anatomical variations of liver arterial supply as detected with multidetector computed tomography in 1,520 patients and its clinical importance. Clin Anat. 2020;33(7):1091-101.

[11] Fonseca-Neto OCLD, Lima HCS, Rabelo P, Melo PSV, Amorim AG, Lacerda CM. Anatomic variations of hepatic artery: a study in 479 liver transplantations. Arq Bras Cir Dig. 2017;30(1):35-37. Doi: 10.1590/0102-6720201700010010.

[12] Ferrari R, De Cecco CN, Iafrate F, Paolantonio P, Rengo M, Laghi A. Anatomical variations of the coeliac trunk and the mesenteric arteries evaluated with 64-row CT angiography. Radiol Med. 2007;112(7):988-98.

[13] Araujo Neto SA, Franca HA, de Mello Júnior CF, Silva Neto EJ, Negromonte GR, Duarte CM et al. Anatomical variations of the celiac trunk and hepatic arterial system: an analysis using multidetector computed tomography angiography. Radiol Bras. 2015;48(6):358-62.

[14] Thangarajah A, Parthasarathy R. Celiac axis, common hepatic and hepatic artery variants as evidenced on MDCT angiography in south Indian population. J Clin Diagn Res. 2016;10(1):TC01-TC05. Doi: 10.7860/JCDR/2016/17045.7105.

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Application form for requesting Waiver of Written Informed Consent/ waiver of consent

(To be filled by PI)

1. Proposal Number :

2. Principal Investigator's name: Dr. Suganya .S

3. Department: Anatomy

4. Title of project:
Anatomical variations in the origin ,course and branching pattern of hepatic artery – Radiological study

5. Names of co-investigators: Haritha Krishnan
Brintha S

6. Request for waiver of informed consent:
Please check the reason(s) for requesting waiver
   1. ✔Research involves 'less than minimal risk'
   2. ✔There is no direct contact between the researcher and participant
   3. Emergency situations
   Any other (please specify)- **RetrospectiveRadiological study**

I hereby assure that the rights of the participants will not be violated.
Following are the measures described in the Protocol for protecting confidentiality of data and privacy of research participant
1.No personal details of patients mentioned in the study
2.No personal details of patients mentioned in images
3.

Undertaking: I hereby declare that contents of the soft and hard copies of this document submitted to the IHEC are the same.

Principal Investigator's signature with date: 12/8/2022