

Prevalence and Anatomical Distribution of Accessory and Replaced Hepatic Arteries: Implications for Hepatobiliary Surgery in Peshawar

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ABSTRACT

Background: Anatomical variations of the hepatic arterial system are frequently encountered during hepatobiliary surgery and may significantly influence operative safety. Accessory and replaced hepatic arteries, if unrecognized, can predispose patients to vascular injury, hepatic ischemia, biliary complications, and postoperative hemorrhage. Population-specific data regarding these variations remain limited in Khyber Pakhtunkhwa.

Objective: To determine the prevalence and anatomical distribution of accessory and replaced hepatic arteries in patients undergoing hepatobiliary surgery in Peshawar and to assess their surgical implications.

Methodology: A prospective observational study was conducted at the Surgical "B" Unit of Khyber Teaching Hospital, Peshawar, over one year, from January 2020 to January 2021. A total of 139 patients undergoing open hepatobiliary surgical procedures were enrolled. Intraoperative identification of accessory and replaced hepatic arteries was performed, and their anatomical characteristics were documented using a structured proforma. Data were analyzed descriptively using SPSS version 25.

Results: Accessory and replaced hepatic arteries were identified in 60 patients (42.8%). Replaced right gastric artery was the most frequent variant (22.0%), followed by accessory right hepatic artery (6.5%) and accessory cystic artery (5.75%). Multiple aberrant arteries were present in 18 patients (12.9%). The distribution of arterial variants was statistically significant ($p < 0.001$).

Conclusion: Accessory and replaced hepatic arteries are common and clinically significant anatomical variations in hepatobiliary surgery. Awareness and careful identification of these vessels are essential to minimize intraoperative complications and to optimize surgical outcomes.

Keywords: Hepatic artery, anatomical variation, accessory artery, replaced artery, hepatobiliary surgery, Peshawar.

INTRODUCTION

The hepatic arterial system constitutes a fundamental component of hepatic perfusion and plays a pivotal role in hepatobiliary surgical procedures. Conventionally, the common hepatic artery originates from the celiac trunk and divides into right and left hepatic arteries after giving rise to the gastroduodenal artery. However, variations in hepatic arterial anatomy are frequently encountered and may significantly influence surgical technique and outcomes⁽¹⁻³⁾.

Accessory hepatic arteries are supplementary vessels that coexist with normal arterial branches, whereas replaced hepatic arteries serve as the sole arterial supply in place of a normally expected vessel. These variations may originate from diverse sources such as the superior mesenteric artery or left gastric artery and can traverse critical anatomical corridors near the bile duct, portal vein, and pancreatic head. Failure to recognize these variants can result in inadvertent vascular injury, hepatic ischemia, biliary complications, hemorrhage, and graft dysfunction in transplant settings⁽⁴⁻⁶⁾.

Hepatobiliary procedures such as cholecystectomy, hepatic resection, pancreaticoduodenectomy, and liver transplantation require precise knowledge of arterial anatomy to ensure operative safety. The presence of multiple aberrant arteries further increases procedural complexity and surgical risk, necessitating careful preoperative planning and meticulous intraoperative dissection⁽⁷⁻⁹⁾.

Despite the recognized clinical importance of hepatic arterial variations, region-specific data from Khyber Pakhtunkhwa remain limited. The present study was therefore designed to determine the prevalence, distribution, and surgical relevance of accessory and replaced hepatic arteries in patients undergoing hepatobiliary surgery at a tertiary care center in Peshawar, with the aim of enhancing surgical awareness and improving patient outcomes.

METHODOLOGY

Study Design and Setting: This prospective observational study was conducted at the Surgical "B" Unit of Khyber Teaching Hospital, Peshawar, in collaboration with other surgical units routinely

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performing hepatobiliary procedures. The study duration spanned one year, from Jan 2020 to Jan 2021 Khyber Teaching Hospital is a major tertiary care referral center catering to patients from Peshawar and adjoining districts of Khyber Pakhtunkhwa, thus providing a representative population for the assessment of hepatobiliary vascular anatomy in this region.

Study Population and Sample Size: A total of 139 consecutive patients undergoing elective or emergency open hepatobiliary surgical procedures were enrolled. Both male and female patients of all age groups were included. The sample size was based on the number of eligible patients presenting during the study period and was considered adequate to evaluate the prevalence and distribution of hepatic arterial variations within the institutional surgical load.

Inclusion and Exclusion Criteria

Inclusion criteria: comprised all patients undergoing open hepatobiliary surgeries, including cholecystectomy, hepatic resections, biliary tract explorations, and pancreaticoduodenectomy, in whom the hepatic arterial anatomy could be clearly visualized intraoperatively.

Exclusion criteria included patients undergoing laparoscopic procedures, individuals with distorted anatomy secondary to severe inflammation, malignancy, or previous upper abdominal surgery where vascular delineation was unreliable, and patients in whom safe dissection of hepatic arterial branches was not feasible.

Data Collection Procedure: Preoperative evaluation included detailed history taking, physical examination, and routine laboratory and radiological investigations as per institutional protocol. Written informed consent was obtained from all participants.

Intraoperatively, careful dissection of the hepatoduodenal ligament was performed to identify the common hepatic artery and its branches. The presence of accessory or replaced hepatic arteries was meticulously documented. The origin, course, branching pattern, and anatomical relationship of each aberrant

artery to adjacent structures particularly the common bile duct, portal vein, and hepatic parenchyma were recorded.

Data were documented using a pre-designed structured proforma. Information included the number of aberrant arteries per patient, type of arterial variation, and perceived surgical relevance such as risk of injury, need for modified dissection, and requirement for vascular preservation or reconstruction.

Surgical Technique: Standard surgical approaches were employed according to the nature of the procedure, including right subcostal (Kocher), extended right subcostal, and midline incisions. Surgeons adhered to meticulous dissection techniques under direct visualization to avoid inadvertent vascular injury. Accessory and replaced arteries were preserved whenever possible to maintain adequate hepatic perfusion.

Ethical Considerations: The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Approval was obtained from the Institutional Ethical Review Committee of Khyber Teaching Hospital prior to initiation of the study. Confidentiality of patient data was strictly maintained throughout the study.

Statistical Analysis: Data were entered and analyzed using Statistical Package for Social Sciences (SPSS) version 25. Descriptive statistics were applied. Categorical variables were expressed as frequencies and percentages. The prevalence and distribution of accessory and replaced hepatic arteries were summarized in tabular form. No inferential statistical testing was applied due to the descriptive nature of the study.

RESULTS

A total of 139 patients undergoing open hepatobiliary surgery were evaluated. Accessory and replaced hepatic arteries were identified in 60 patients, yielding an overall prevalence of 42.8%. The remaining 79 patients (57.2%) exhibited conventional hepatic arterial anatomy.

The distribution of individual arterial variations is summarized in Table 1. Replaced right gastric artery (RRGA) was the most frequently encountered variant, present in 30 patients (22.0%), followed by accessory right hepatic artery (ARHA) in 9 patients (6.5%) and accessory cystic artery (ACA) in 8 patients (5.75%). The overall distribution of arterial variants showed a statistically significant deviation from uniform distribution (χ^2 test, $p < 0.001$).

Patients were stratified according to the number of aberrant hepatic arteries detected intraoperatively (Table 2). A single aberrant artery was present in 18 patients (12.8%), two aberrant arteries in 16 patients (11.5%), and three aberrant arteries in 2 patients (1.4%). The frequency of multiple aberrant arteries showed a statistically significant decreasing trend with increasing number of arteries ($p = 0.002$).

Accessory and replaced hepatic arteries were frequently found in close proximity to the common bile duct and portal vein. Their presence necessitated meticulous surgical dissection to prevent vascular compromise and biliary injury. Patients harboring multiple aberrant arteries required modified surgical strategies to preserve adequate hepatic perfusion. No major vascular complications were recorded when these arteries were identified and preserved appropriately.

Table 1. Prevalence of Accessory and Replaced Hepatic Arteries (n = 139)

Artery Type	Number of Cases	Percentage (%)
Accessory Right Hepatic Artery (ARHA)	9	6.5
Accessory Cystic Artery (ACA)	8	5.75
Replaced Right Gastric Artery (RRGA)	30	22.0
Total Cases with Any Aberrant Artery	60	42.8

$p < 0.001$ (Chi-square goodness-of-fit test)

Table 2. Number of Aberrant Hepatic Arteries per Patient (n = 139)

Number of Aberrant Arteries	Number of Cases	Percentage (%)
Single	18	12.8
Two	16	11.5
Three	2	1.4

$p = 0.002$ (Chi-square test for trend)

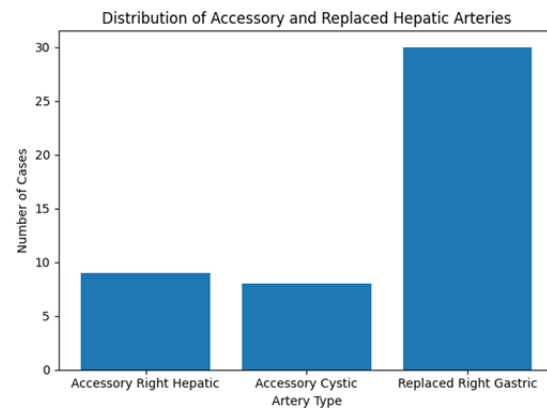


Figure 1. Distribution of accessory and replaced hepatic arteries among the study population (n = 139).

DISCUSSION

The present study provides valuable region-specific data on the prevalence and anatomical distribution of accessory and replaced hepatic arteries in patients undergoing open hepatobiliary surgery in Peshawar. The overall prevalence of aberrant hepatic arteries observed in this study was 42.8%, indicating that nearly half of the surgical population possessed one or more arterial variations. This finding emphasizes the clinical importance of routinely anticipating vascular anomalies during hepatobiliary procedures^(8,10-12).

The predominance of replaced right gastric artery as the most frequent variant in this cohort (22.0%) is noteworthy. Comparable international studies have reported prevalence rates ranging between 15% and 30%, suggesting that the frequency observed in the present population falls within the higher end of the reported spectrum. The presence of accessory right hepatic arteries (6.5%) and accessory cystic arteries (5.75%) also aligns with global anatomical literature, which recognizes these vessels as common but surgically critical variants⁽¹³⁻¹⁵⁾.

The identification of multiple aberrant arteries in 15.7% of patients further highlights the complexity of hepatic vascular anatomy. These patients represent a high-risk subgroup in whom inadvertent vascular injury may compromise hepatic perfusion, predispose to biliary ischemia, or result in postoperative hemorrhage. The statistically significant trend toward decreasing frequency with increasing number of aberrant arteries suggests that while multiple variants are less common, their surgical relevance is substantial⁽¹⁶⁻¹⁸⁾.

From a practical surgical perspective, unrecognized accessory or replaced arteries may lead to partial liver ischemia, biliary strictures, bile leaks, and in transplant settings, graft dysfunction or failure. The findings of this study reinforce the importance of meticulous intraoperative dissection and preoperative imaging where feasible to delineate vascular anatomy. Incorporating routine vascular mapping into surgical planning may substantially reduce iatrogenic complications^(19,20).

Furthermore, the regional data generated by this study fill an important knowledge gap for surgeons practicing in Khyber Pakhtunkhwa and adjoining areas, where population-specific anatomical variation has previously been under-reported. These findings can serve as a foundation for refining surgical training curricula and institutional protocols to enhance operative safety.

CONCLUSION

Accessory and replaced hepatic arteries are common anatomical variations in patients undergoing hepatobiliary surgery, with an overall prevalence of 42.8% in the present cohort. Replaced right gastric artery was the most frequent variant encountered. The presence of multiple aberrant arteries further increases operative complexity and risk.

Awareness and careful identification of these vascular variations are essential to minimize intraoperative complications, preserve hepatic perfusion, and improve surgical outcomes. Routine consideration of hepatic arterial variants should form an integral part of preoperative planning and intraoperative decision-making in hepatobiliary surgery.

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