

**A CADAVERIC STUDY ON VARIATIONS OF THE CYSTIC ARTERY IN
THE DEPARTMENT OF PATHOLOGY, AT THE UNIVERSITY
TEACHING HOSPITALS, LUSAKA, ZAMBIA**

By

Isaac Sing`ombe

**A Dissertation Submitted in partial Fulfilment of the requirements for the Degree of
Master of Science in Human Anatomy**

The University of Zambia

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2019

DECLARATION

I **Isaac Sing`ombe**, declare that this Dissertation represents my own work and that all the sources I have quoted have been indicated and acknowledged by means of complete reference. I further declare that this Dissertation has not previously been submitted for a Degree or Diploma or other qualifications at this or other University. It has been prepared in accordance with the guidelines for Master of Science Degree in Human Anatomy Dissertations of the University of Zambia.

Signed (Candidate)_____ **Date**_____

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APPROVAL

The University of Zambia approves this dissertation on a Cadaveric Study on Variations of the Cystic Artery in the Department of Pathology, at the University Teaching Hospitals, Lusaka, Zambia in a partial fulfillment of the Master of Science Degree in Human Anatomy.

Examiner 1 _____ Signature _____ Date _____

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Examiner 3 _____ Signature _____ Date _____

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Supervisor _____ Signature _____ Date _____

ABSTRACT

The main source of blood supply to the gall bladder is the cystic artery which is a branch of the right hepatic artery. Anatomical variations of the cystic artery are frequent. Thus, careful dissection of the Calot's triangle is necessary for conventional and laparoscopic cholecystectomy. The knowledge of variations of the origin, course, and length of the cystic artery is important for the surgeon as bleeding from the cystic artery during cholecystectomy can lead to death.

The objectives of the study were; 1. To establish the origin of the cystic artery. 2. To determine the length of the cystic artery. 3. To establish the course of the cystic artery. 4. To establish the relationship of the cystic artery to the cystic duct.

This was a descriptive cross-sectional study design in which 32 post-mortem human cadavers at the University Teaching Hospitals, Pathology Department, Lusaka were dissected and examined over a period of five weeks. A data collection form was used as a tool to gather the data and sample selection was done through systematic sampling. Data was entered and analyzed using Statistical Package for Social Sciences Statistics, version 22.0 (SPSS). A Chi-square and Fisher's test was used to test association between variables. The cadavers dissected were aged between 22 and 66 years (mean 36.06 ± 11.992) and of the 32, 27 were males and 5 females.

Out of the 32 human cadavers, the cystic artery was found to be originating from the right hepatic artery in twenty-eight (87.5%), from hepatic artery proper in three (9.4%) and from the left hepatic artery in one (3.1%). In the twenty-nine (90.6%) cadavers dissected only one cystic artery was identified and in three (9.4%) others there were two arteries detected. The cystic artery length ranged from 2 – 6 cm (mean 3.56 ± 1.0285 cm). The cystic artery was found to be inside Calot's triangle in twenty-seven (84.3%) while in three (9.4%) it was outside the Calot's triangle. The cystic artery was found to be passing supero-medial to the cystic duct in thirty (93.8%) while in two (6.3%) the cystic artery was passing anterior to the cystic duct. Demographic characteristic (gender and age) had no statistically significant association to variations of cystic artery ($p > 0.005$). Five (18.5%) of males had variants of cystic artery and no females had variants of the cystic artery.

Variations of the cystic artery origin, length, its course through the Calot`s triangle and its relation to the cystic duct are common. Knowledge of these variations is important and helpful in preventing and controlling haemorrhage or avoiding other complications during conventional and laparoscopic cholecystectomy.

Key words: Cystic artery, Variations, Calot`s triangle, Cholecystectomy

DEDICATION

To the Almighty God for giving me life and strength to complete this dissertation.

To my parents for their encouragement, support and prayers to enable me complete this project.

To my lovely wife, Gift Chimya Mulenga Sing`ombe for her love, encouragement, inspiration and support.

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TABLE OF CONTENT

DECLARATION	ii
COPYRIGHT	iii
APPROVAL	iv
ABSTRACT	v
DEDICATION	vii
ACKNOWLEDGEMENTS	viii
TABLE OF CONTENT	ix
LIST OF FIGURES	xii
LIST OF TABLES	xiii
LIST OF APPENDICES	xiv
ABBREVIATIONS	xv

CHAPTER ONE

INTRODUCTION	1
1.1 Statement of the Problem.....	4
1.2 Significance of the Study.....	5
1.3 Research Objectives.....	6
1.3.1 General Objective.....	6
1.3.2 Specific Objectives.....	6
1.4 Research Question.....	6

CHAPTER TWO

LITERATURE REVIEW	7
2.1 Introduction.....	7
2.2 Variations of the Cystic artery.....	7

CHAPTER THREE

METHODOLOGY	14
3.1 Study Design.....	14
3.2 Study Sample.....	14

3.3 Sample Size.....	14
3.4 Study Population.....	15
3.4.1 Inclusion Criteria.....	15
3.4.2 Exclusion Criteria.....	15
3.5 Data Collection.....	15
3.6 Data Analysis Plan.....	16
3.7 Ethical Consideration.....	17
3.8 Limitations of the Research.....	17

CHAPTER FOUR

DATA ANALYSIS AND PRESENTATION OF RESULTS.....	18
4.1 Introduction.....	18
4.2 Data analysis.....	18
4.3 Presentation of results.....	18
4.4 Dissemination of the results.....	18
4.5 Demographic Data and Cystic artery data.....	18
4.6 Origin of Cystic Artery.....	19
4.7 Cystic Artery Variations.....	22

CHAPTER FIVE

DISCUSSION OF THE FINDINGS.....	25
5.1 Introduction.....	25
5.2 Demographic Characteristics.....	25
5.3 Number of Cystic Arteries.....	26
5.4 Origin of Cystic Artery.....	27
5.5 Length of Cystic Artery.....	27
5.6 Course of Cystic Artery in the Calot's triangle.....	28
5.7 Relation of the Cystic artery to the cystic duct.....	28

5.8 Relationship between variation of Cystic Artery and demographic characteristics.....	29
5. 9 Conclusion.....	30
5.10 Recommendation.....	31
5.11 Utilization and dissemination of results.....	31
REFERENCES.....	32
APPENDICES.....	36

LIST OF FIGURES

Figure 1: Cysto-hepatic Triangle (of Calot).....	1
Figure 2: Blood Supply to the Gall Bladder	2
Figure 3: Sub-hepatic Region shows the lesser omentum where the CA is embedded.....	5
Figure 4: Origin of cystic artery.....	20
Figure 5: Cystic artery (within the Calot`s triangle) originating from right hepatic artery.....	22
Figure 6: Anomalous origin of the cystic artery (Double cystic artery) from the right hepatic artery and hepatic artery proper.....	23
Figure 7: Anomalous origin of the cystic artery (Double cystic artery) from the right hepatic artery.....	23
Figure 8: Anomalous origin of the cystic artery from the hepatic artery proper.....	24

LIST OF TABLES

Table 1: Variables.....	16
Table 2: Data Analysis Plan.....	17
Table 3: Demographic Characteristics of Data.....	19
Table 4: Number of Cystic Arteries.....	19
Table 5: Length of Cystic Artery.....	20
Table 6: Course of Cystic Artery.....	21
Table 7: Relation of Cystic Artery to the Cystic duct.....	21
Table 8: Range, Mean and Standard Deviation for Age and length of cystic artery.....	21
Table 9: Relationship between variation of Cystic Artery and demographic characteristic.....	22
Table 10: Comparison of origin of cystic artery with other studies.....	29
Table 11: Comparison of the cystic artery course to the Calot's triangle with other studies.....	30
Table 12: Comparison of the cystic artery length with other studies.....	30

LIST OF APPENDICES

Appendix 1: Approval letter from Assistant Dean Postgraduate.....	36
Appendix 2: Approval letter from ERES Converge.....	37
Appendix 3: Letter of permission and approval to conduct research at UTH.....	39
Appendix 4: Information Sheet for Relatives.....	40
Appendix 5: Consent Form.....	42
Appendix 6: Data Collection Form.....	43
Appendix 7: Dissection instruments and Digital Vernier Caliper: used to measure the length of the Cystic artery.....	45

ABBREVIATIONS

CA	Cystic Artery
CBD	Common Bile Duct
CD	Cystic Duct
CHA	Common Hepatic Artery
CHD	Common Hepatic Duct
GB	Gall Bladder
GDA	Gastroduodenal Artery
HAP	Hepatic Artery Proper
LHA	Left Hepatic Artery
LP	Liver Parenchyma
REC	Research Ethics Committee
RHA	Right Hepatic Artery
SMA	Superior Mesenteric Artery
SPSS	Statistical Package for Social Sciences
UTH	University Teaching Hospital

CHAPTER ONE INTRODUCTION

The chief source of blood supply to the gallbladder and the cystic duct is the cystic artery (Tejaswi *et al.*, 2013). The cystic artery (CA) is a single vessel that originates from the right branch of the proper hepatic artery (PHA). It usually passes through the hepatobiliary triangle or Calot's triangle, which is bounded superiorly by the inferior surface of the liver, inferiorly by the cystic duct and medially by the common hepatic duct (Polgui *et al.*, 2014). (Figure 1). Dr. Calot initially described the superior border of the Calot's triangle as being bounded by the cystic artery (Chen *et al.*, 2000). On approaching the gallbladder, the cystic artery divides into superficial and deep branches that run on the anterior and posterior surfaces of the gallbladder (Polgui *et al.*, 2014).

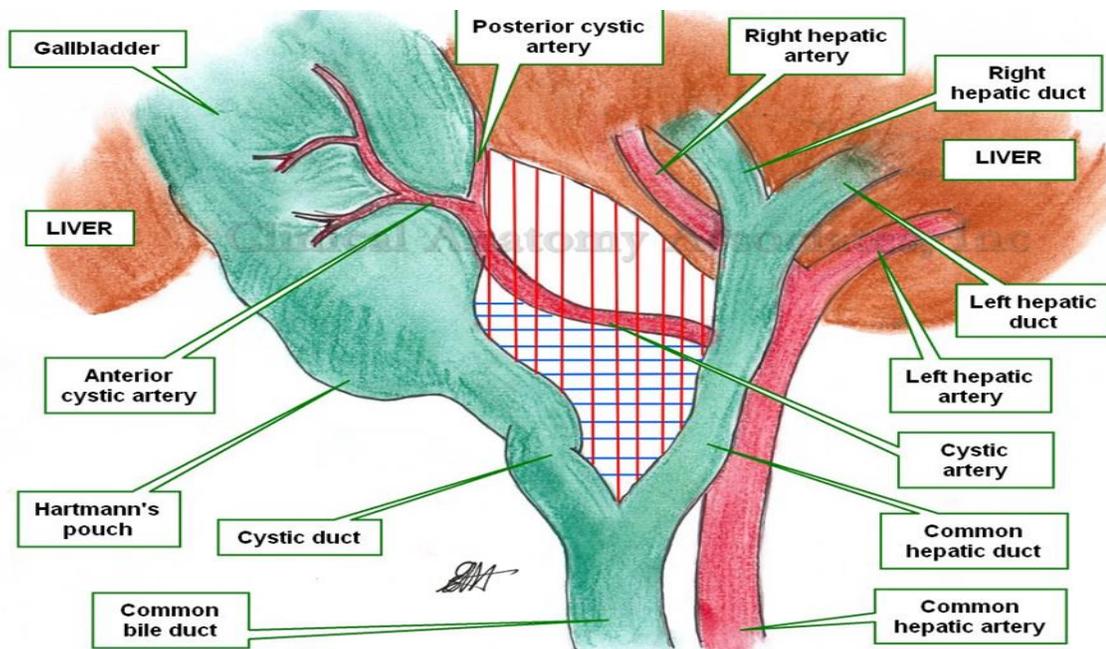


Figure 1: Cystohepatic Triangle (of Calot)

Source: "Triangle of Calot" Efrain A Miranda, Clin Anat. (2016)

Anatomical variations of the cystic artery are commonly encountered during cholecystectomy. In Approximately 80% of individuals, the cystic artery arises from the right hepatic artery. The other origins include the left hepatic artery, the proper hepatic artery, the common hepatic artery, the gastroduodenal artery, the superior

pancreaticoduodenal artery and the superior mesenteric artery (Sarkar and Roy, 2000). In addition to the variability in origin of the cystic artery, its course can also follow diverse paths, often in close proximity to the common bile duct (Sarkar and Roy, 2000). Ding *et al.*, (2007) classified variations of the cystic artery as follows;

Group I - represents the Calot's triangle type, in which the cystic artery passes through Calot's triangle. Group I is further subdivided into two subtypes.

a). Classical single cystic artery: The cystic artery originates from the right hepatic artery within Calot's triangle and the artery divides into deep and superficial branches at the neck of the gallbladder. The superficial branch proceeds along the left side of the gallbladder. The deep branch runs through the connective tissues between the gallbladder and liver parenchyma as shown in Figure 2. The deep branch gives rise to tiny branches to supply the gallbladder, which anastomose with the superficial branches. This type of cystic artery is laterally positioned from the cystic duct within Calot's triangle during open cholecystectomy, whereas during laparoscopic cholecystectomy it is just behind and slightly deeper than the cystic duct. This type is found in 70% - 80% of cases.

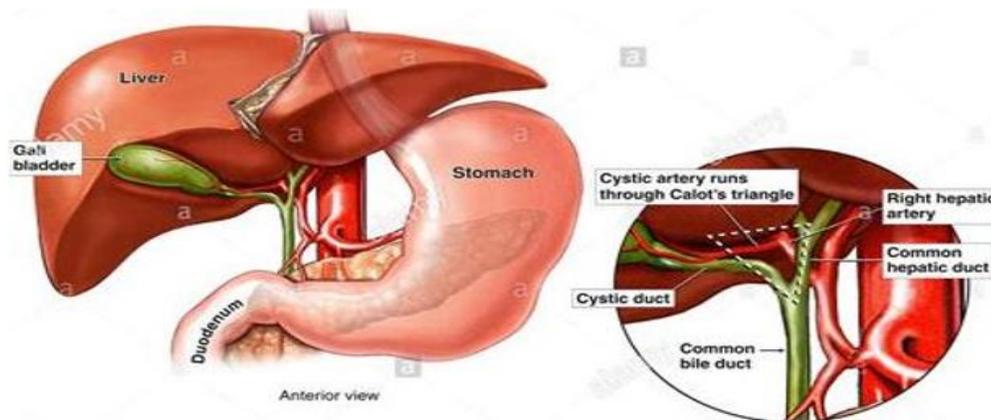


Figure 2: Blood Supply to the Gall Bladder (Cystic Artery)

Source:<http://www.alamy.com/stock-photo-anatomy-of-the-liver-gallbladder-and-biliary-system>

b). Double cystic artery: The CA also originates from the right hepatic artery and divides into the anterior and posterior branches at its origin. Congenital absence of the posterior branch signifies the existence of another CA, which is occasionally detected by subsequent

bleeding control. The posterior cystic artery is very delicate in some cases and is often cut by electrocoagulation during dissection. A double CA has previously been found in 15% - 25% of patients.

Group II: The CA approaches the gallbladder outside Calot's triangle and cannot be observed within the triangle by laparoscopy during dissection. This group includes the following four subgroups.

a). Cystic artery originating from gastro-duodenal artery: This type of CA is also called low-lying cystic artery, which does not pass through Calot's triangle but approaches the gallbladder below it. In conventional open cholecystectomy it is seen as inferior to the cystic duct, while it is usually localized superficially and anterior to the cystic duct from a laparoscopic viewpoint.

b). Cystic artery originating from the variant right hepatic artery: Anatomic variation of the right hepatic artery usually originates from the superior mesenteric artery or aorta. It enters Calot's triangle behind the portal vein, and runs parallel to the cystic duct on its passage through the triangle. It can be completely covered by the cystic duct of the gallbladder.

c). Cystic artery originating directly from the liver parenchyma: This cystic artery pierces the hepatic parenchyma approaching the gall bladder from the gallbladder bed. It is usually situated in the right lateral border of the gallbladder body. No other arteries are found within Calot's triangle. This anatomical variation of the cystic artery is not observed until bleeding and is caused by dissection of the gallbladder fundus. It is difficult to explore and requires careful dissection.

d). Cystic artery originating from the left hepatic artery: The cystic artery occasionally originates from the left hepatic artery, passes through the liver parenchyma, and reaches the middle of the gallbladder body, at which point it bifurcates into ascending and descending branches.

Group III: This group has more than one blood supply and was named compound cystic artery type. Therefore, cystic arteries exist not only in Calot's triangle, but also outside it.

The knowledge of variations in the origin and course of cystic artery is important for the surgeons as uncontrolled bleeding from the cystic artery and its branches can be fatal during cholecystectomy. Intra-operative bleeding can result in an increase in the risk of intra operative injury to vital vascular and biliary structures (Tejaswi *et al.*, 2013).

1.1 Statement of the Problem

A good knowledge of Calot's triangle is important for conventional and laparoscopic cholecystectomy. Calot's triangle is an important imaginary referent area for biliary surgery (Ding *et al.*, 2007). Cystic artery bleeding is a wearisome complication during laparoscopic cholecystectomy, which increases the rate of conversion to open surgery. If surgery is performed incorrectly, injury to the extra-hepatic bile duct or intra-abdominal organs may occur (Ding *et al.*, 2007). Laparoscopic cholecystectomy has been accepted as the preferred method of treatment of gall bladder stones in healthy individuals all over the world. During laparoscopic cholecystectomy, dissection is in a limited field but is magnified on the video monitor and offers a different perspective compared to open cholecystectomy. Under these circumstances inadvertent injury may occur particularly to the cystic duct. In order to minimize the likelihood of injury to the bile duct a detailed knowledge of the anatomy of the area and variations of the cystic artery becomes important to the surgeon (Hugh and Kelly, 1992) (Sarkar and Roy, 2000). The CA is the key structure sought to be clipped or ligated during laparoscopic or conventional cholecystectomy. The possible complications like haemorrhage or hepatobiliary injury are always centered on the search, dissection, and clipping or ligation of CA because of variations of the artery and its proximity to the bile duct (Dandekar and Dandekar, 2016).

Knowledge of the variant vascular anatomy of the sub-hepatic region as shown in Figure 3 is important for hepatobiliary surgeons in limiting operative complications due to unexpected bleeding (Saidi *et al.*, 2007). All these recurring complications are a reason of appeal for surgeons, radiologists, and anatomists to study cystic artery anatomy persistently so that they can be aware of the variations and thus avoid complications.

In Zambia, at the University Teaching Hospital (UTH), laparoscopic cholecystectomy is being carried out for treatment of cholelithiasis. At UTH there were 50 laparoscopic cholecystectomies and 22 open cholecystectomies performed from 1st May 2015 to 8th

November 2017. Of the 22 open cholecystectomies, 8 were male and 14 female patients. Out of the 50 laparoscopic cholecystectomies two were converted to open cholecystectomy due to bleeding. Some of the complications experienced by the surgeons during the cholecystectomy were; injury to the liver and nearby structures such as the stomach, mistaking the right hepatic artery as a cystic duct and bleeding (Unpublished UTH Theater Register Data, 2017). There is also inadequate documentation or literature on the variations of the cystic artery. It is for this reason that this research was conducted on cadavers at the University Teaching Hospitals in Lusaka.

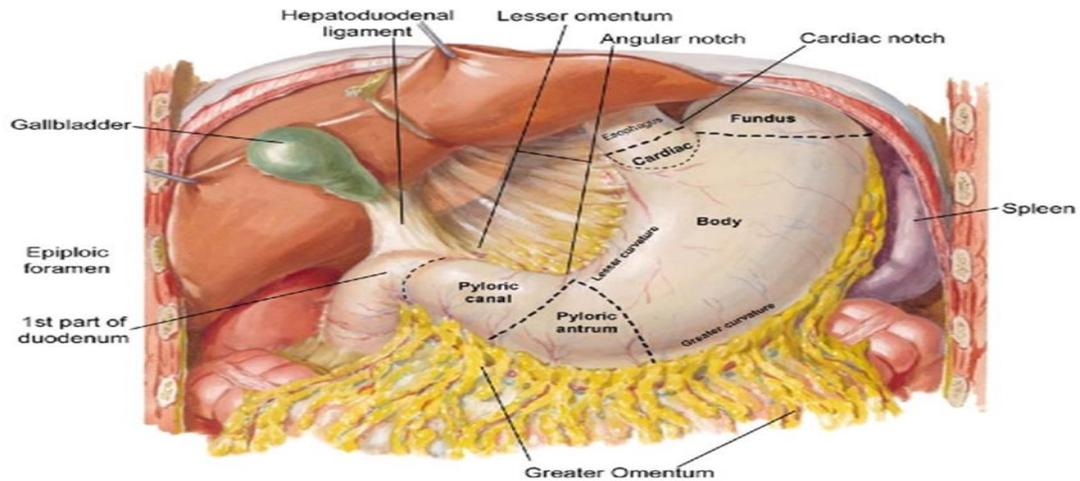


Figure 3: Sub-hepatic Region shows the lesser omentum where the CA is embedded
Source: <http://www.alamy.com/stock-photo-anatomy-of-the-liver-gallbladder> and lesser omentum.

1.2 Significance of the Study

Variations of the origin and course of the cystic artery are very common. Thus, since laparoscopic cholecystectomy became the gold standard for treatment of cholelithiasis, knowledge of anatomical variations of the hepatobiliary arterial system has gained in importance (Ding *et al.*, 2007). Blood vessel injuries during laparoscopic cholecystectomy, including cystic artery bleeding, result in conversion to open surgery in up to 1.9 % of cases, causing mortality of about 0.02 % (Ding *et al.*, 2007). Awareness of other possible

anomalies in this region is of great importance for safe cholecystectomy as well as for proper interpretation of liver arteriograms (Polgui *et al.*, 2014).

Identification of the cystic and hepatic arteries is important for interventional radiologists who perform arterial embolization and chemoperfusion of unresectable hepatic tumours (Kavitha, 2015). The principle of accurate identification of the vascular structures also applies in surgical practice. Thus, for safe and uneventful cholecystectomy, especially by means of laparoscopic techniques, it is important to be familiar with anatomic variations in the hepatobiliary arterial system (Polgui *et al.*, 2014).

The importance of this study was to determine the variations of the cystic artery. The findings from this study will help minimize accidental injury to the bile duct, cystic artery and avoid haemorrhagic complications.

1.3 Research Objectives

1.3.1 General Objectives

To explore the anatomical variations of the cystic artery in cadavers. A study conducted at the Department of Pathology, University Teaching Hospitals, Lusaka, Zambia.

1.3.2 Specific Objectives

1. To establish the origin of the cystic artery.
2. To determine the length of the cystic artery.
3. To establish the course of the cystic artery.
4. To establish the relationship of the cystic artery to the cystic duct.

1.4 Research Question

What are the variations of the cystic artery as observed in a series of autopsies performed in the Department of Pathology, University Teaching Hospitals, Lusaka, Zambia?

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The cystic artery usually arises from the right hepatic artery. It has a variable length and enters the gallbladder in the neck or body area. The course and length of the cystic artery in the Calot's triangle is variable. Although classically the artery traverses the triangle almost through its center, it can occasionally be very close or even lower than the cystic duct (Patil *et al.*, 2013). The cystic artery is known to exhibit variations in its origin and branching pattern. This is attributed to the developmental changes occurring in the primitive ventral splanchnic arteries (Hiaing *et al.*, 2011). The source of blood supply to the gall bladder and the cystic duct is the cystic artery which is usually a branch of right hepatic artery. It may arise from the left hepatic artery, gastroduodenal artery or superior mesenteric artery (Gawali, 2014).

2.2 Variations of the Cystic Artery

Andall *et al.* (2016) conducted a study titled, the clinical anatomy of cystic artery variations: a review of over 9800 cases. The purpose of the study was to determine the anatomical variations of the cystic artery. The findings were as follows; CA originated from the right hepatic artery (79.02%) and found in the hepatobiliary triangle in 81.5% cases. Short cystic arteries were found in 9.5% cases and multiple cystic arteries in 8.9% cases. The researchers concluded that variations are common in the general population and can lead to inadvertent ligation of biliary ducts or aberrant vessels. They further concluded that, it is important for the hepatobiliary surgeon to be aware of these vascular anomalies to avoid operative complications.

Dandekar *et al.* (2016) conducted a study titled, cystic artery: morphological study and surgical significance on 82 adult formalin embalmed cadavers. The study focused on the origin, number, length, course and position of the CA with reference to Calot's triangle. The findings were as follows; CA originated from right hepatic artery in 79.3%, aberrant right hepatic artery in 12.1%, hepatic artery proper in 3.7%, common hepatic artery in 2.5%, middle hepatic artery in 1.2%, and from left hepatic artery in 1.2% of the cadavers.

The length ranged between 2 mm and 55mm and 3.6% of the cases did not enter in the Calot's triangle. The researchers concluded that it is crucial for the surgeon to give careful attention, identify, and confirm the cystic artery before clipping or ligation.

In Iran at Tehran University of Medical Sciences, Enyi *et al.* (2015) reported a variation of the gallbladder vasculature including double cystic arteries. This rare anatomical variation of the hepatobiliary arterial system was found during anatomical dissection of a female Iranian formalin embalmed cadaver. Two cystic arteries were present, the first arising directly from the right hepatic artery and the second from the gastroduodenal artery. The common hepatic artery originated from a coeliac trunk and branched into gastroduodenal artery and proper hepatic artery. The proper hepatic artery bifurcated into right and left branches. At the level of the junction of the common hepatic duct with the cystic duct, the right hepatic artery gave rise to the cystic artery. The gastroduodenal artery travelled inferiorly and gave rise to the accessory cystic artery. The accessory cystic artery ascended supero-laterally, coming from the middle part of the gallbladder. Then, it bifurcated into superficial and deep branches. The researchers concluded that knowledge of the different anatomical variations of the arterial supply of the gallbladder is of great importance in hepatobiliary surgical procedures.

Kavitha (2015) reported a case titled: 'Dual Cystic Arteries in Association with Caterpillar Hump of Right Hepatic Artery – A Case Report and its Surgical Relevance'. This variation was found during routine dissection of abdomen in an adult female formalin embalmed cadaver where dual cystic arteries and tortuous hepatic arteries were seen. A short cystic artery arose from the proximal part of the distal loop of right hepatic artery within the hepatobiliary triangle which supplied the visceral surface of the gall bladder and a long cystic artery arising outside the hepatobiliary triangle from the proximal part of superior pancreaticoduodenal branch of gastroduodenal artery. The long artery crossed the common bile duct anteriorly and was lying superficial to the cystic duct up to the neck of the gall bladder beyond which it was related to the peritoneal surface of the gall bladder supplying it. It was concluded by the researchers that a sound knowledge of such vascular variations is essential for surgeons to prevent iatrogenic injuries in this region and conversion of

laparoscopic to open cholecystectomy thus reducing mortality and morbidity due to intra and postoperative complications.

Gawali (2014) conducted a study on variations of origins and course of the Cystic artery and its relations to the Calot's triangle in 30 formalin embalmed cadavers at Seth GS Medical College, Mumbai, India. The aims of the study were; to note the origin and number of cystic artery, relation of the cystic artery to the Calot's triangle, cystic duct and common hepatic duct. The results were as follows; the Cystic artery was found originating from the right hepatic artery in twenty-seven (97%) cadavers, from the left hepatic artery, aberrant right hepatic artery and gastro-duodenal artery in one (3.33%) each. Cystic artery was found to be inside the Calot's triangle in twenty-seven (97%) while in three (10%) cadavers it was outside the Calot's triangle. Cystic artery was crossing anterior to the common hepatic duct in fourteen (46.66%) and in fifteen (50%) cadavers it was passing posterior to the common hepatic duct. Cystic artery was found to be passing anterior to the cystic duct in three cadavers (10%). It was concluded by the researchers that awareness of these variations can prevent potential intraoperative and postoperative complications.

Nayeemuddin *et al.* (2014) reported a case on variant anatomy of the cystic artery that was observed on 50-year-old female and 55-year-old male formalin embalmed cadavers during routine cadaveric dissection for medical undergraduates in India. In the female cadaver, the cystic artery originated from the left hepatic artery; the common hepatic artery took origin from coeliac trunk and divided into right and left hepatic arteries. The right hepatic artery after giving branch to right lobe of the liver continued as a right cystic artery which was supplying the anterior surface of gall bladder. The left hepatic artery after giving branches to left lobe continued as a left cystic artery supplying the posterior surface of gall bladder. The researchers concluded that anatomical knowledge of arterial supply of extrahepatic biliary ductal system and its variations is important for surgeons to reduce the incidence of accidents during laparoscopic cholecystectomy.

In India at Maulana Azad Medical College, Patil *et al.* (2013) reported a case that was found during routine cadaveric dissection for medical undergraduates, a variation in the origin of cystic artery in a 57-year-old female formalin embalmed cadaver. It was observed that the cystic artery originated from the coeliac trunk. The coeliac trunk gave rise to

following branches: left gastric artery, splenic artery, common hepatic artery and also a cystic artery. The cystic artery after its origin from the coeliac trunk was passing posterior to the portal vein and the common hepatic duct, then running through the Calot's triangle and reaching the gall bladder. It was concluded by the researchers that it is important to have a thorough knowledge of the cystic arterial variations that may be encountered during laparoscopic and open cholecystectomy thus avoiding injuries to biliary structures and vessels which may lead to uncontrolled bleeding.

Another case was reported by Hiaing *et al.* (2011) in Singapore which was titled a Unique Origin of the Cystic artery. This unique origin was found in a male formalin embalmed cadaver during routine dissection where the CA originated from a "middle hepatic" artery and the middle hepatic artery originated from the right hepatic artery. The origin of the CA was located to the left of the common hepatic duct, outside the Calot's triangle. The CA traversed for a distance of 1.5 cm, giving off a branch to the cystic duct and then passed anterior to the cystic duct. The researchers concluded that the topographical anatomy of the arterial system of the hepatobiliary region and their anomalous origin should be considered during hepatobiliary surgeries. The researchers concluded that knowledge is also important for interventional radiologists in routine clinical practice.

Pushpalatha (2010) carried out a study of variations in the origin of the cystic artery. This study was done on 35 embalmed cadavers and 15 fresh postmortem specimens. In this study the findings were as follows; in 54% of the cadavers the cystic artery originated from the right hepatic artery, from hepatic artery proper 22%, from common hepatic in 12%, from gastro-duodenal in 8% and from the superior mesenteric in 2% of the cadavers. It was also observed that the cystic artery arising from the superior mesenteric artery passed across head of the pancreas. The researchers concluded that such variations are important for surgeons to know during resection to avoid haemorrhage.

In Iraq at the College of Medicine, University of Babylon, Al-Sayigh Haythem (2010) carried out a study on the incidence of cystic artery variation during laparoscopic surgery. The aim of the study was to describe the common variant anatomy related to the cystic artery during laparoscopic cholecystectomy so that to minimize anatomical complications and to recommend an anatomically safe procedure. The study involved 50 patients who

underwent laparoscopic cholecystectomy and the findings were as follows; females constituted 84% of the patients. Routine preoperative ultrasound examination revealed gallstones in 86% of the patients and 18% of the cases demonstrated anomalous vascular anatomy. The researchers concluded that surgeons should rely on good anatomical knowledge to avoid subhepatic injuries medially during cholecystectomy.

Vishnumaya *et al.* (2008) in a case report described a cystic artery with an anomalous origin from gastro-duodenal artery. This variation was found during a routine dissection of a 34-year-old male formalin embalmed cadaver, where the cystic artery had an origin from the gastro-duodenal artery 2.5cm distal to the origin of common hepatic artery. It was concluded by the researchers that knowledge of vascular variations is important during the operative, diagnostic and endovascular procedures in the abdomen.

Loukas *et al.* (2006) reported a rare case of double cystic arteries arising from both the right hepatic artery and the proximal part of the posterior superior pancreaticoduodenal artery. The title of the case report was Multiple Variations of the Hepatobiliary Vasculature including double Cystic arteries, accessory left Hepatic artery and Hepatosplenic trunk. In this study the researchers concluded that anatomical knowledge of the cystic artery is important because anatomical variations in the origin and branching pattern of the hepatobiliary arterial system may be encountered during both conventional surgical and laparoscopic cholecystectomy.

Mlakar *et al.* (2003) studied the anatomical variations of the cystic artery in 81 formalin embalmed cadavers. Their main aim was to investigate the origin of the cystic artery. The results were as follows; the gallbladder was supplied by one cystic artery in 86% and by two arteries in 14% of cadavers. It was observed that a single artery originated from the right hepatic artery in 53% of livers and when two cystic arteries supplied the gallbladder, both originated from the right hepatic artery (7%). Other origins included the anterior and posterior sectional hepatic artery.

Suzuki *et al.* (2000) also conducted a study titled laparoscopic cholecystectomy, Calot's triangle and variations in cystic arterial supply. In this study 244 laparoscopic cholecystectomies were performed and studied over a period of 2 years. The results were

as follows; in one hundred and eight-seven (76.6%) of the cases a typical arterial supply anteromedial to the cystic duct was found, twenty-seven (11.1%) had no cystic artery in Calot`s triangle and in eighteen (7.4%) cases accessory arteries were observed. It was concluded by the researchers that young surgeons who are not yet familiar with the handling of an anatomically abnormal cystic blood supply need to be more aware of the precise anatomy of the extrahepatic biliary tree.

Chen *et al.* (2000) conducted a study on the variations of the cystic artery in Chinese adults. The aim of the study was to determine the origin and course of the cystic artery in relation to the Calot`s triangle. The results from the 70 autopsies done were as follows; of all the cystic arteries, 86.1% coursed through the Calot`s triangle and 100% of the cystic arteries originating from the right hepatic artery coursed through the Calot`s triangle. Fifty-four percent of the Cystic arteries that originated from the left, bifurcation, proper, and common hepatic arteries ran through the triangle. None of the cystic arteries that originated from the gastro-duodenal, coeliac, superior mesenteric artery, or superior pancreaticoduodenal arteries passed through the triangle. A conclusion was made by the researchers that information about anatomical variation in Chinese adults may help avoid injury during open or laparoscopic cholecystectomies.

In Sudan, Bakheit (2009) conducted a study on the prevalence of variations of the cystic artery. This study also looked at the variations in the origin of the cystic artery and its location in relation to the biliary ducts among 106 Sudanese people and compared the variations between the sexes and races. The researchers found that the cystic artery originated from the right hepatic artery in 78% of cadavers, common hepatic artery in 17%, left hepatic artery in 2% and the gastro-duodenal artery in 3%. No differences were found between the sexes.

Another study was done by Saidi *et al.* (2007) on 102 formalin embalmed cadavers; variant anatomy of the cystic artery in adult Kenyans. The results were as follows; CA originated from the right hepatic artery in 92.2% of cadaver and the rest were aberrant and originated from the proper hepatic artery. The researchers concluded that knowledge of the variant vascular anatomy of the subhepatic region is important for hepatobiliary surgeons in limiting operative complications due to unexpected bleeding.

Fatara *et al.* (2001) also carried out a study in Ethiopia which was titled; Variations of the Hepatic and Cystic arteries among Ethiopians. The aim of the study was to investigate the anatomy of the hepatic and cystic arteries in 110 postmortem and cadaveric subjects. It was found that the cystic artery mainly originated from the right hepatic artery eighty-three (75.5%) but also originated from the middle hepatic artery fourteen (12.7%), gastroduodenal artery eight (7.3%) or the left hepatic artery five (4.5%). It was also observed that there were 11 accessory cystic arteries arising from the right hepatic in six cadavers (54.5%), the middle hepatic three cadavers (27.2%) or the left hepatic arteries two cadavers (18.1%). The researchers concluded that arterial variations seen in this study were significantly higher than that reported in the literature. This was mainly due to the variations seen in origin of the right hepatic artery in the female subjects than in the male subjects and that the significance of this finding needs further investigation.

CHAPTER THREE RESEARCH METHODOLOGY

3.1 Study Design

This was a cross sectional descriptive study that was conducted at the University Teaching Hospital, Pathology Department. The study took five (5) weeks to complete.

3.2 Study Sample

Male and female non embalmed cadavers located in the Pathology department (forensic postmortem cases) and aged between 18 and 75 years.

3.3 Sample Size

The sample size was calculated using the formula;

$$N = \frac{Z^2 \times P(1-P)}{d^2}$$

N = Sample required

Z = Z statistic for a given level of confidence = 1.96 when using a 95% CI

P = expected prevalence of the condition in the population being studied; prevalence of variations of the cystic artery is 14%.

d = confidence interval, 0.05 (+/- 5%)

$$n = \frac{1.96^2 \times 0.14 \times (1 - 0.14)}{(0.05)^2}$$

$$n = 3.8416 \times 0.14 \times 0.86 / 0.0025$$

$$n = 0.4625 / 0.0025 = 185$$

$$n = n/1 + n/N$$

$$n = 185/1 + 185/30$$

$$n = 185/6.1 = 30$$

None response rate was calculated at 5%. $5/100 \times 30 = 2$ cadavers.

Sample Size = 30 + 2 = 32

3.4 Study Population

Male and female non embalmed cadavers (forensic postmortem cases) from the Department of Pathology, University Teaching Hospitals, Lusaka.

3.4.1 Inclusion criteria

- Post-pubertal development continues up to the age of 18 + or – 2 depending on gender. For this reason, male and female cadavers aged between 18 and 75 years were included in the study. Age was determined from autopsy and police data.
- Cadavers collected within 48 hours of death as postmortem changes tend to progress after 48 hours.

3.4.2 Exclusion criteria

- Cadavers with abdominal trauma and evidence of injuries or lesions to vessels and associated adjacent organ pathology such as cholecystitis and pancreatitis were excluded.

3.5 Data Collection

Data collection was through a data collection form and sample selection was done through systematic sampling. The average number of forensic postmortem cases per month is 108, that is; 27 per week and 6 per day in the University Teaching Hospitals, Lusaka. Thus data was collected every week, $27/6 = 4$. This implies that every fourth cadaver being dissected during postmortem was included in the study.

From the non-embalmed cadavers (postmortem cases); the peritoneal cavity was explored after removing the anterior layer of peritoneum from the lesser curvature of the stomach. The lesser omentum was dissected and then the sub-hepatic region of the abdomen was exposed. The fundus of the gall bladder was held with a swab and stick or hand. The gall bladder was pulled cephalic, laterally and anterior and this required an assistant. After this the foramen of Winslow was identified and then a Hagers dilator or a rubber tube e.g. FG 12 Foley catheter was placed through the opening without force and left there as a guide. The peritoneum covering the Calot's Triangle was carefully opened leading to exposure of the cystic duct. With further fine dissection, the CA was identified and helped in following it to its origin. The origin, length, and course of the CA along with its position with reference to Calot's triangle were recorded. Length was measured using a Vernier Caliper.

In addition to this, its relations to biliary ducts were also noted. Findings of every cadaveric dissection was recorded and extensively photographed.

3.6 Data Analysis Plan

The data obtained was tabulated and analyzed using the SPSS (Statistical Package for Social Sciences Statistics, version 22.0) program. The dependent variable is variations of the CA which is categorical and independent variables are age, gender, course, length and origin as shown in Table 1. The distribution for the variations among males and females was noted. The Chi square test was used to describe categorical variables. Mean and standard deviation were used to describe continuous variables. See Table 2. Values of $P < 0.05$ were considered to be significant. If significant, the binary regression analysis was used to establish relationship between cystic artery and gender.

Table 1: Variables

Independent Variables	Scale of Measurement	Dependent
Race	Categorical	Variations of the cystic artery
Course	Categorical	Class I Classical single cystic artery Double cystic artery Class II CA originating from the gastro-duodenal artery, variant hepatic artery, originating directly from the liver parenchyma, and left hepatic artery Class III Compound Cystic Artery
Length	Continuous	
Origin	Categorical	

Table 2: Data Analysis Plan

	Statistical Package for Social Sciences Version 22		Variables	
Goals of Analysis	Normal Distribution	If not normally Distributed	Variable	Indicator
To describe categorical variables	Chi Square		Course	Inside the Calot's triangle
To describe continuous variables	Mean + SD	Median	Length	2cm – 4cm
To determine the relationship between cystic artery and the cystic duct	Pearson's Correlation	Spearman's Correlation	Origin	Right Hepatic artery

3.7 Ethical Consideration

Ethical clearance was obtained from ERES Converge. Permission to conduct the study was obtained from the Department of Pathology, University Teaching Hospitals. Cadavers were treated with respect, dignity and Confidentiality was maintained and permission was sought from the relatives. Safety measures were implemented such as wearing of gloves, plastic aprons and gum boots when dissecting the cadaver to prevent acquiring diseases. The findings of the research were only confined to this particular study.

3.8 Limitations of the Research

Differentiating the right hepatic artery from the cystic duct during the dissection of the extra-hepatic region and the abdominal cavity was difficult. The cadavers were predominantly male. The reason for this is unknown. It is postulated that females are less likely to be involved in criminal activities which may lead to an increased likelihood of accidents; assaults and suicides which require autopsies.

CHAPTER FOUR

DATA ANALYSIS AND PRESENTATION OF RESULTS

4.1 Introduction

This chapter analyses and presents the study findings which were collected using data collection form. The results are presented in frequency tables, bar chart and figures.

4.2 Data analysis

Data were collected, coded, entered and analyzed using Statistical Package for Social Sciences Statistics, version 22.0 (SPSS). A Chi-square and Fisher`s test was used to test association between predictor and outcome variables. The confidence Interval (CI) of 95% was set and a p-value of < 0.05 was considered statistically significant.

4.3 Presentation of results

The results of the study have been presented according to the sections on the data collection form. Data is grouped according to the variables under discussion. The results are presented using the frequency tables, figures and cross-tabulations to explain the research results. The cross-tabulations have been used to demonstrate relationship between variables.

4.4 Dissemination of the results

The results of the study were presented to the School of Medicine, University of Zambia (UNZA) and postgraduate seminar week at UNZA Ridgeway campus. Five copies of the bound research report were printed and submitted to the School of Medicine, UNZA Medical Library and Main Library, Ministry of Health, University Teaching Hospital (Adult) and a copy for the researcher.

4.5 Demographic Data and Cystic Artery Data

Table 3 shows that majority twenty-seven (84.4%) of the cadavers were males. The findings were expected as there are more postmortems being done on males than females. The age range was between 22 and 66 years. Thirteen (40.6%) cadavers were aged between 20 – 30 years and 31 – 40 years respectively while three (9.4%) of the cadavers were aged between 41 – 50 years and 61 – 70 years respectively. All thirty-two (100%) cadavers were black Zambians.

Table 3: Demographic Characteristics of Data

Characteristics	Number	Percentage
Gender		
Male	27	84.4
Female	5	15.6
Total	32	100
Age		
20 – 30 years	13	40.6
31 – 40 years	13	40.6
41 – 50 years	3	9.4
61 – 70 years	3	9.4
Total	32	100
Race		
Black Zambian	32	100

Table 4 shows that majority of the cadaver gall bladders twenty-nine (90.6%) had a single cystic artery while three (9.4%) had double cystic arterial supply.

Table 4: Number of Cystic Arteries

Characteristics	Number	Percentage
Single Cystic Artery	29	90.6
Double Cystic Artery	3	9.4
Total	32	100

4.6 Origin of Cystic Artery

Figure 4 shows that in the majority twenty-eight (87.5%) the cystic artery originated from the right hepatic artery while three (9.4%) were originating from the hepatic artery proper. In one (3.1%) the cystic artery originated from the left hepatic artery.

RHA – Right Hepatic Artery, LHA – Left Hepatic Artery, HAP – Hepatic Artery Proper.

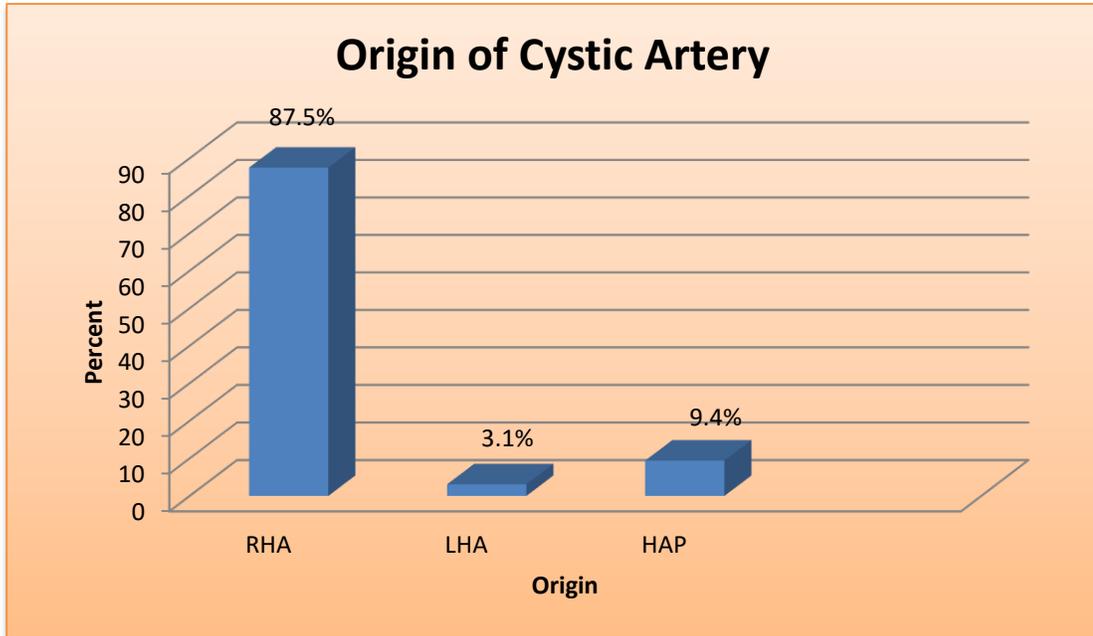


Figure 4 – Origin of Cystic Artery

Table 5 shows that in the majority Twenty-five (78.1%) of the cadavers the cystic artery length was between 2 and 4 cm while seven (21.9%) in the rest of the cystic artery length was above 4 cm.

Table 5: Length of Cystic Artery

Characteristics	Number	Percentage
2 – 4 cm	25	78.1
Above 4 cm	7	21.9
Total	32	100

Table 6 shows that majority twenty-seven (84.3%) of the cystic arteries were passing through the Calot`s triangle while three (9.4%) of the cystic arteries were passing outside the Calot`s triangle. The table also shows that two (6.3%) were double cystic arteries and were one artery originating from the RHA was passing within the Calot`s triangle and the other branch from the Hepatic artery proper was passing outside the Calot`s triangle.

Table 6: Course of Cystic Artery

Characteristics	Number	Percentage
Within the Calot`s Triangle	27	84.3
Outside the Calot`s Triangle	3	9.4
Within and outside the Calot`s Triangle	2	6.3
Total	32	100

Table 7 shows that in thirty cadavers (93.7%) the cystic artery was supero-medial to the cystic duct while two (6.3%) the cystic artery was anterior to the cystic duct.

Table 7: Relation of Cystic Artery to the Cystic duct

Characteristics	Number	Percentage
Cystic Artery Anterior to the Cystic duct	2	6.3
Cystic Artery supero-medial to the Cystic duct	30	93.7
Total	32	100

Table 8 shows the age range 22 – 66 years, and mean age - 36.06. The cystic artery length ranged from 2.00 – 6.00 cm and mean length - 3.56.

Table 8: Range, Mean and Standard Deviation for Age of Cadaver and Length of Cystic artery

Characteristic	Minimum	Maximum	Mean	Std. Deviation
Age	22	66	36.06	11.992
Length of Cystic Artery	2.00	6.00	3.56	1.0285

Table 9 shows that demographic characteristics (gender and age) had no statistically significant association to variations of cystic artery ($p>0.005$). Five (18.5%) of males had variants of cystic artery while no females had variants of the cystic artery.

Table 9: Relationship between variation of Cystic Artery and demographic characteristics

Characteristic		Variation of Cystic Artery			Chi-square	p-value
		Normal	Abnormal	Total		
Gender	Male	22(81.5%)	5(18.5%)	27(100%)	1.097	0.401
	Female	5(100%)	0(0%)	5(100%)		
	Total	27(84.4%)	5(15.6%)	32(100%)		
Age	20 - 35	15(83.3%)	3(16.7%)	18 (100%)	0.034	0.624
	Above 35	12(85.7%)	2(14.3%)	14(100%)		
	Total	27(84.4%)	5(15.6%)	32 (100%)		

4.7 Cystic Artery Variations

Variations of the cystic artery are very common (Ding et al, 2007). In the current study variations or anomalies of the cystic artery origin, length, course and the cystic artery relationship to the cystic duct were found in the 32 cadavers that were dissected and studied as shown in Figure 5, 6, 7 and 8.

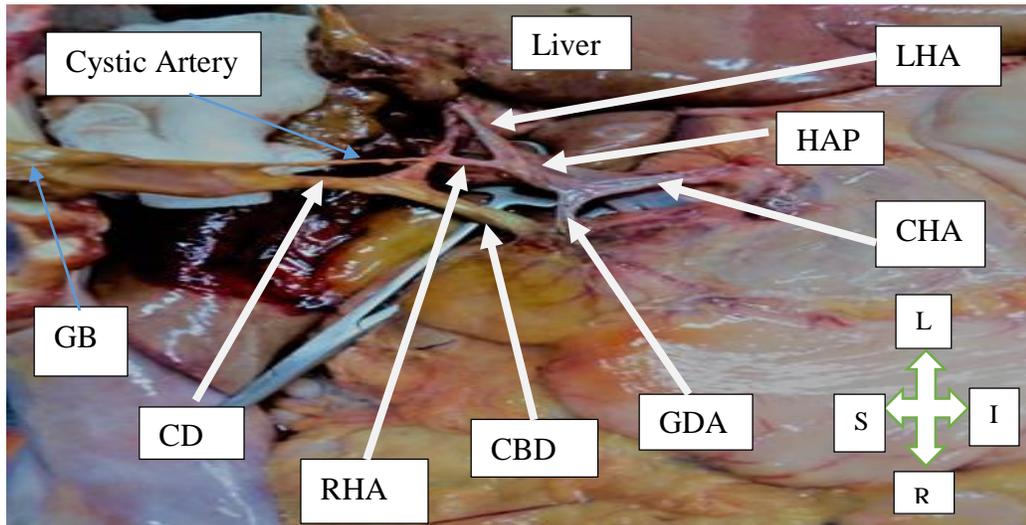


Figure 5: Cystic artery (within the Calot's triangle) originating from right hepatic artery (RHA). GB – gall bladder, CD – cystic duct, CBD – common bile duct, GDA – gastro-duodenal artery, CHA – common hepatic duct, HAP - Hepatic artery proper, LHA – left hepatic artery, S – Superior, I – Inferior, L – Left and R – Right.

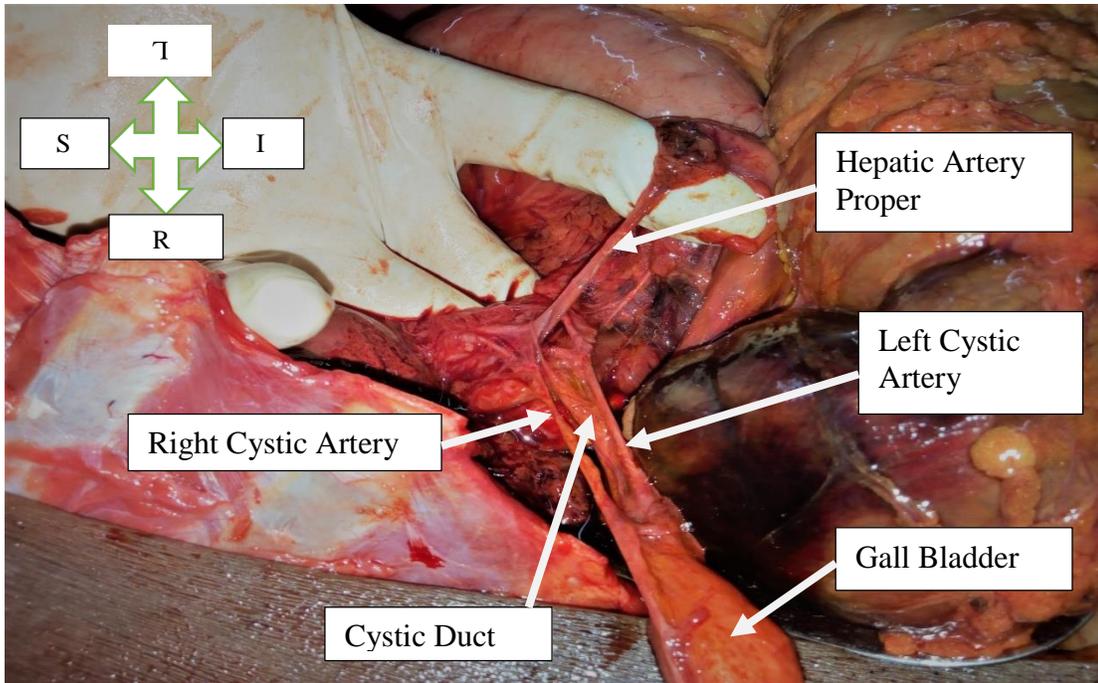


Figure 6: Anomalous origin of the CA (Double cystic artery) from the right hepatic artery (within Calot`s triangle) and hepatic artery proper and anomalous course of the CA originating from the hepatic artery proper (outside Calot`s triangle). S – Superior, I – Inferior, L – Left and R – Right.

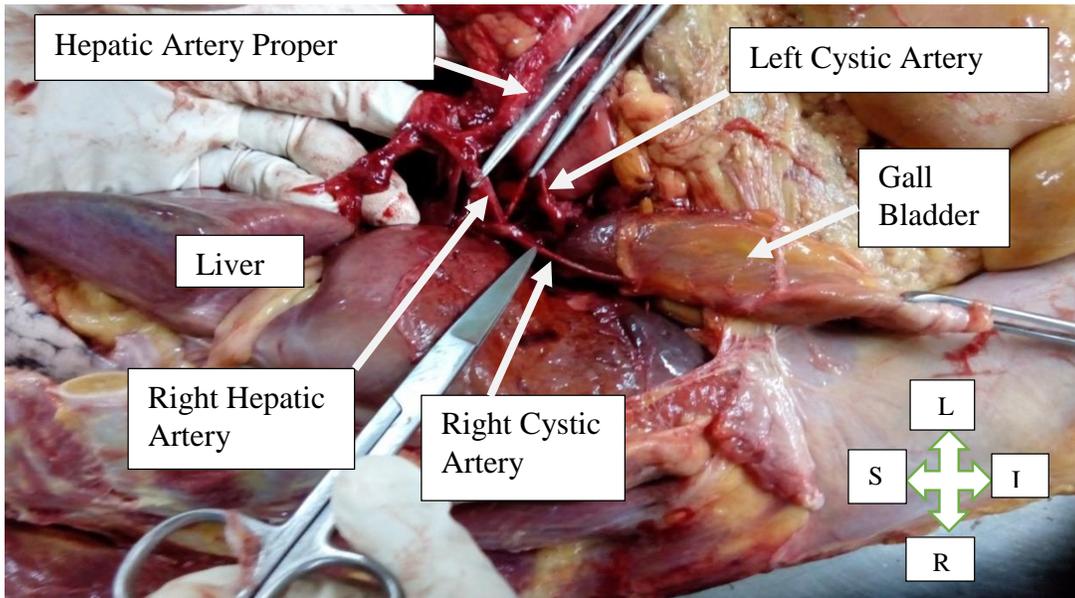


Figure 7: Anomalous origin of the CA (Double cystic artery) from the right hepatic artery (within the Calot`s triangle). S – Superior, I – Inferior, L – Left and R – Right.

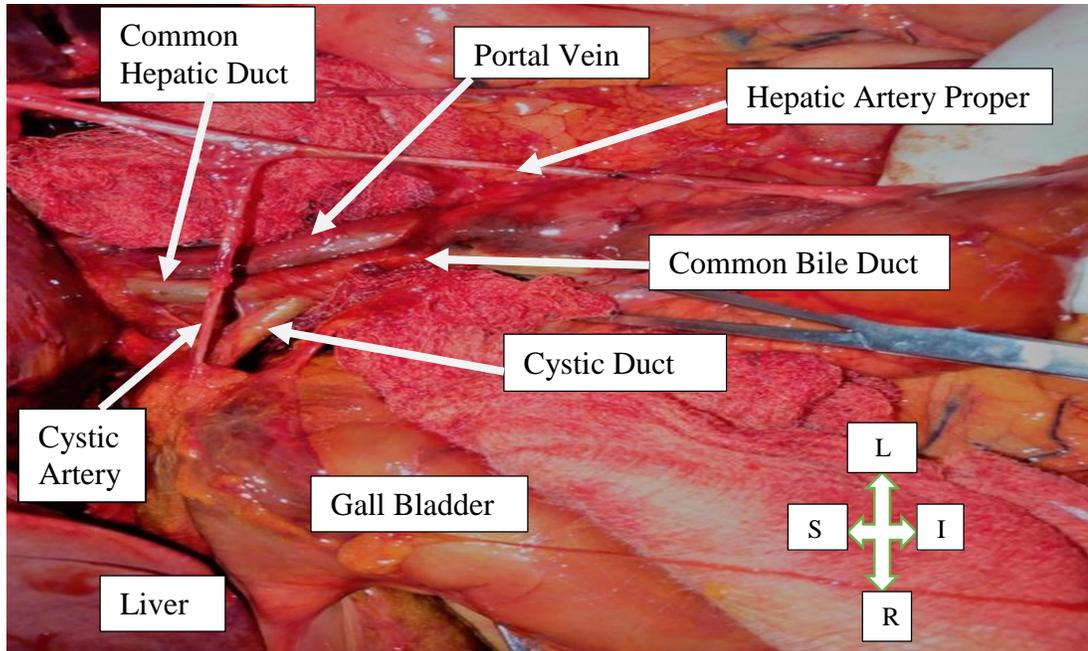


Figure 8: Anomalous origin of the cystic artery from the hepatic artery proper.
S – Superior, I – Inferior, L – Left and R – Right.

CHAPTER FIVE

DISCUSSION OF THE FINDINGS

5.1 Introduction

This chapter discusses the results of the study on a cadaveric study on variations of the cystic artery in a Zambian population. The study describes origin and course of the cystic artery through the Calot's triangle. It also measured the length of the cystic artery from its origin to the gall bladder and the relationship between the cystic artery and cystic duct was described. This study was conducted on forensic postmortem cadavers at the University Teaching Hospitals, Lusaka.

5.2 Demographic Characteristics

Gender

The results in Table 1 showed that majority twenty-seven (84.4%) of the cadavers were males while five (15.6%) were females. This finding is in conformity with the study done by Dandekar U and Dandekar K (2016) who discussed cystic artery morphology and the surgical significance of their findings. Seventy-two (87.8%) of the cadavers in this study were males while ten (12.2%) were females. According to a UTH Log Book Data recorded by one surgeon (1999 - 2003), there were 55 gall bladder surgeries (open cholecystectomies) and out of the 55 patients, 14 were male and 41 were female. These data are in contrast with the findings in autopsy series (Table 1) where the bodies were predominantly male. The reason for this difference is unclear but could be attributed to the presumption that males are more likely to be involved in criminal activities leading to premature death and subsequent autopsies. For biliary system surgeries, there were eight male patients and seven female patients.

Age

The age range was between 22 and 66 years and thirteen (40.6%) of the cadavers were aged between 20 – 30 years and 31 – 40 years respectively while three (9.4%) of the cadavers were aged between 41 – 50 years and 61 – 70 years respectively (mean 36.06 ± 11.992). The current study results are different from a study conducted by Tejaswi

et al (2013) on prevalence of anatomical variations of cystic artery in South Indian cadavers. The authors found that the cadavers were in the age group of 30 – 79 years.

5.3 Number of Cystic Arteries

The results in Table 2 show that in the majority of the cadavers the gall bladder was supplied by a single cystic artery twenty-nine (90.6%) and three (9.4%) had a double cystic artery supply. The results are similar to a study carried out by Mlakar et al (2003) on anatomical variations of the cystic artery. The authors found that the gallbladder was supplied by one cystic artery in 86% and by two arteries in 14% of cases. Another similar study was conducted by Ding et al (2007) on new classification of the anatomic variations of cystic artery during laparoscopic cholecystectomy which found that seventy-three of the six hundred patients (12.2%) had double cystic artery. Gawali (2014) found similar results in a study on variations of origin and course of the cystic artery and its relation to the Calot`s triangle was 88.8% of the cases had one cystic artery while 13.3% had two cystic arteries. In contrast, Hugh et al (1992) conducted a study on laparoscopic anatomy of the cystic artery which found that 72% of the patients had a normal cystic artery while 22% had doubling of the cystic artery. Eyni et al (2015) reported a case on variation of the gall bladder vasculature including double cystic arteries which was found during dissection of a female cadaver. Two cystic arteries were present, first arising directly from the right hepatic artery and the second from the gastro-duodenal artery.

Dual cystic artery identification and ligation of both arteries is necessary during cholecystectomy. After ligating or clipping one artery, surgeons must search carefully for possibility of another supply which may have any source of origin and if not identified, may be torn and bleeding may obscure the operating field. Uncontrolled bleeding from cystic artery is a serious problem which can lead to intraoperative injuries to vital vessels and biliary tract. The resulting haemorrhage and bile leakage usually constitute the most common causes of conversion of laparoscopic cholecystectomy to open cholecystectomy and mortality (Kavitha, 2015).

5.4 Origin of Cystic Artery

The results in Table 3 shows that majority twenty-eight (87.5%) of the cystic arteries originated from the right hepatic artery while three (9.4%) originated from the hepatic artery proper. One (3.1%) originated from the left hepatic artery. The results are similar to the study conducted by Ding et al (2007) on a new classification of the anatomic variations of cystic artery during laparoscopic cholecystectomy; they found that five hundred and thirteen of the six hundred patients (85.5%) observed had the cystic artery originating from the right hepatic artery, 3% arising from the variant right hepatic artery, 7.5% from the gastro-duodenal artery. Aristotle (2014) reported similar findings in a study on variations in origin and course of cystic artery and clinical implications of the cystic artery and its relations to Calot's triangle. In 92.5% of the cases the cystic artery arose from the right hepatic artery, 5% from the hepatic artery proper and 2.5% from the common hepatic artery. In another study conducted by Pushpalatha (2010) on variation in the origin of the cystic artery, the results were somewhat different as out of 50 cadavers dissected only 54% of the cases had the cystic artery originating from the right hepatic artery, 22% arose from hepatic artery proper, 12% from the common hepatic artery, 8% from gastro-duodenal artery and 2% from superior mesenteric artery. Fatara et al (2001) found different results in a study on variations of the hepatic and cystic arteries among Ethiopians - the cystic artery originated from the right hepatic artery in 75.5%, from the middle hepatic artery in 12.7%, gastro-duodenal artery 7.3%, and left hepatic artery in 4.5%.

The aforementioned data indicate that variations in the origin, course and distribution of the cystic artery have a large number of variations. An operating surgeon must be familiar with these variations to avoid inadvertent injuries during control, ligation, clipping and division of vessels and the consequent morbidity associated with surgery (Dandekar U and Dandekar K, 2016).

5.5 Length of Cystic Artery

Table 4 showed that majority twenty-five (78.1%) of the cadavers the cystic artery length was between 2 and 4 cm while seven (21.9%) of the cadavers the cystic artery length was above 4 cm. The cystic artery length ranged from 2 – 6 cm (mean 3.56 ± 1.0285 cm). In contrast, Dandekar U and Dandekar K (2016) in a study on cystic artery: morphological

study and surgical significance found that the cystic artery length ranged from 0.2 – 5.5 cm (mean 1.69 cm). Another study conducted by Tejaswi et al (2013) on prevalence of anatomical variations of the cystic artery in South Indian cadavers found different results were the cystic artery length ranged from 0.37 – 4.2 cm (mean 1.76 cm). Surgeons should be aware of such short type variations as the length has a bearing on the type of clip to be used and the security with which a ligature is applied to the cystic artery.

5.6 Course of Cystic Artery in the Calot`s triangle

The results in Table 5 showed that majority twenty-seven (84.3%) of the cystic arteries were passing through the Calot`s triangle while three (9.4%) of the cystic arteries were passing outside the Calot`s triangle. The table also showed that two (6.3%) were double cystic arteries and where one artery was originating from the RHA and passing within the Calot`s triangle and the other branch from the hepatic artery proper was passing outside the Calot`s triangle. The findings of this study were similar to Aristotle (2014) on variations in origin and course of cystic artery and its relations to Calot`s triangle with its clinical implications which showed that 92.5% of the cases the cystic artery was coursing through the Calot`s triangle while 10% of the cases the cystic artery coursed outside the Calot`s triangle. Another study conducted by Chen et al (2000) found similar results were the cystic artery in 86.1% cases coursed through the Calot`s triangle while 13.9% of the cases the cystic artery coursed outside the Calot`s triangle. Fatara et al (2001) found similar results in a study on variations of the hepatic and cystic arteries among Ethiopians were the cystic artery passed in Calot`s triangle in 81% cases while in 19% of cases the cystic artery coursed outside the Calot`s triangle. In contrast, Tejaswi et al (2013) found different results in a study on the prevalence of anatomical variations of cystic artery in South Indian cadavers were the cystic artery in 65% cases was found inside the Calot`s triangle and in 35% outside the triangle. These findings emphasize the importance of knowledge of Calot`s triangle and the variations thereof.

5.7 Relation of the Cystic artery to the cystic duct

The results in Table 7 showed that in thirty (93.7%) cadavers the cystic artery was superomedial to the cystic duct and in two (6.3%) the cystic artery was anterior to the cystic duct. In Gawali`s (2014) study the cystic artery was noted to be passing anterior to

the cystic duct in three (10%) and in twenty-seven (90%) of the cadavers it was not related to the cystic duct. Another study which was contrary to the present study was conducted by Andall et al (2015) in which over 9 800 cases were reviewed and the cystic artery was found to be located “inferior” to the cystic duct in thirty-eight (4.9%) of cases.

5.8 Relationship between variation of Cystic Artery and demographic Characteristics

The results in Table 9 showed that demographic characteristics (gender and age) had no statistically significant association to variations of cystic artery ($p>0.005$). Five (18.5%) of males had variants of cystic artery while no females had variants of the cystic artery. In contrast, Torres et al (2009) conducted a study on the course of the cystic artery during laparoscopic cholecystectomy were they found that significant frequent variants of the cystic artery were observed in the females.

Table 10 shows the differences in the origin of the cystic artery as found by other researchers with the current study. RHA – Right hepatic artery, HAP – Hepatic artery proper, LHA – Left hepatic Artery, LP – Liver parenchyma, GDA – Gastro-duodenal artery, CHA - Common hepatic artery, SMA – Superior mesenteric artery.

Table 10: Comparison of origin cystic artery with other studies

No	Studies	No of Cadavers	Origin of Cystic Artery						
			RHA	HAP	LHA	LP	GDA	CHA	SMA
1	Present study	32	28	3	1	0	0	0	0
2	S Aristole ¹	40	38	2	0	0	0	1	0
3	Tejaswi et al ²	100	92	0	1	0	1	0	0
4	K Pushpalatha ¹	50	27	11	0	0	4	6	2

Table 11 shows different findings of the course of the cystic artery through the Calot’s triangle by researchers.

Table 11: Comparison of the cystic artery course to the Calot's triangle with other studies

No	Studies	Number of Cadavers	Relationship to the Calot's Triangle	
			Inside	Outside
1	Present Study	32	27	3
2	Badshah et al ³	65	44	21
3	Futara et al ²	110	89	21
4	R Gawali ¹	30	27	3

Table 12 shows different lengths of the cystic artery as found by other researchers and compared with the current study findings

Table 12: Comparison of Length of cystic artery with other studies

No	Studies	Number of Cadavers	Mean	Average length (Range)
1	Present Study	32	3.56 cm	2 – 6 cm
2	Tejaswi et al ²	100	1.76 cm	0.37 – 4.2 cm
3	Dandekar et al ¹	82	1.69 cm	0.2 – 5.5 cm

5.9 Conclusion

The cystic artery is an important anatomical structure to be isolated and ligated during laparoscopic or conventional cholecystectomy. The objective of the study was to explore the anatomical variations of the cystic artery in the Zambian population. The results of the study showed that: twenty-seven (84.4%) of the cadavers were males and five (15.6%) were females. The gall bladder was supplied by a single cystic artery in twenty-nine (90.6%) and three (9.4%) had a double cystic artery. The cystic artery originated from the right hepatic artery in twenty-eight (87.5%), three (9.4%) originated from hepatic artery proper, one (3.1%) originated from the left hepatic artery. In twenty-five (78.1%) cadavers the cystic artery length was between 2 and 4 cm and in seven (21.9%) it was longer than 4 cm. The cystic artery length ranged from 2 – 6 cm (mean 3.56± 1.0285 cm). In twenty-

seven (84.3%) cadavers the cystic artery was passing through Calot`s triangle while in three (9.4%) the arteries were passing outside the Calot`s triangle and two (6.3%) were double cystic arteries; were one artery originating from the RHA was passing within the Calot`s triangle and the other branch from the Hepatic artery proper was passing outside the Calot`s triangle. In thirty (93.7%) the cystic artery was supero-medial to the cystic duct and two (6.3%) the cystic was anterior to the cystic duct. Demographic characteristic (gender and age) had no statistically significant association to variations of cystic artery ($p>0.005$). Five (18.5%) of males had variants of cystic artery and no females had variants of the cystic artery.

5.10 Recommendations

1. A study should be conducted on a female population to establish the pattern of variations of the cystic artery.
2. Further studies should be conducted to investigate the branching or division of the cystic artery and its relationship to the extra-hepatic ductal system.

5.11 Utilization and dissemination of results

The results of the study should be disseminated to surgeons and anatomists:

1. For surgeon`s knowledge and awareness of variations of the cystic artery can contribute towards limiting the likelihood of injury, haemorrhage and bile duct leakage during cholecystectomy.
2. For Anatomists who teach gross anatomy such knowledge of variations should become an integral part of clinically oriented courses in medical schools.

Results of the study were presented to the post-graduate seminar week in October 2018 at the University of Zambia, Ridgeway campus and to the Department of Anatomy (UNZA) and Surgery, University Teaching Hospitals, Lusaka. The research article was submitted for possible publication in peer reviewed journals such as International Anatomical or Surgical journals. The researcher disseminated the results of the study by submitting bound copies of the study documents to the following: - University of Zambia Medical library; the Main Campus Library; School of Medicine; Ministry of Health and the University Teaching Hospitals.

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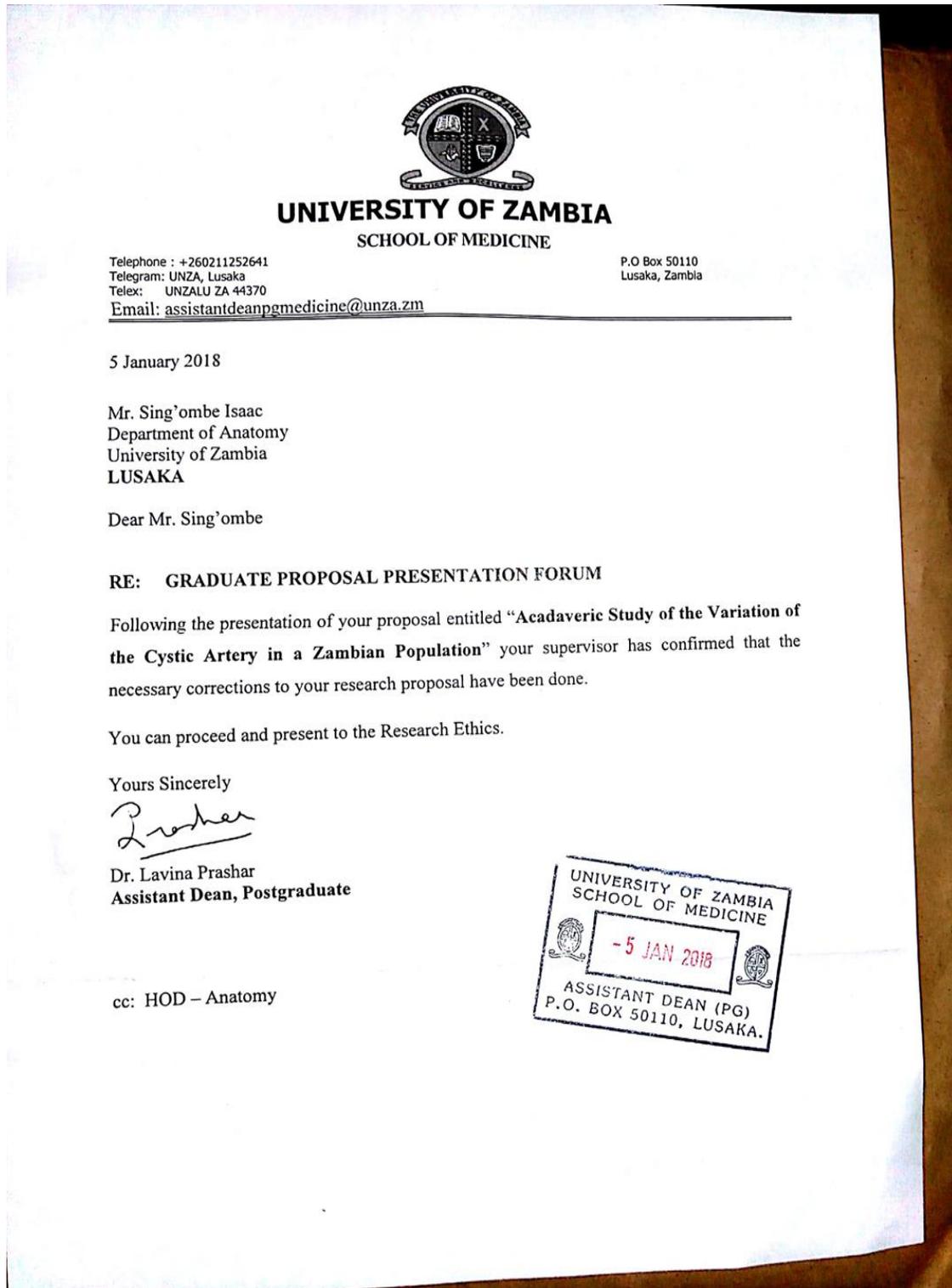
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APPENDICES

APPENDIX 1: Approval letter from Assistant Dean Postgraduate



APPENDIX 2: Approval letter from ERES Converge



33 Joseph Mwilwa Road
Rhodes Park, Lusaka
Tel: + 260 955 155 633
+ 260 955 155 634
Cell: + 260 966 765 503
Email: eresconverge@yahoo.co.uk

I.R.B. No. 00005948
E.W.A. No. 00011697

25th January, 2018

Ref. No. 2017-Nov-024

The Principal Investigator
Mr. Isaac Sing'ombe
The University of Zambia
School of Medicine
Dept. of Human Anatomy
P.O. Box 50110,
LUSAKA.

APPROVED
25 JAN 2018
ERES CONVERGE
P/BAG 125, LUSAKA

Dear Mr. Sing'ombe,

**RE: ANATOMICAL VARIATIONS OF THE CYSTIC ARTERY AT THE
UNIVERSITY TEACHING HOSPITAL, LUSAKA, ZAMBIA**

Reference is made to your corrections. The IRB resolved to approve this study and your participation as Principal Investigator for a period of one year.

Review Type	Ordinary	Approval No. 2016-Nov-024
Approval and Expiry Date	Approval Date: 25 th January, 2018	Expiry Date: 24 th January, 2019
Protocol Version and Date	Version - Nil	24 th January, 2019
Information Sheet, Consent Forms and Dates	• English	24 th January, 2019
Consent form ID and Date	Version - Nil	24 th January, 2019
Recruitment Materials	Nil	24 th January, 2019
Other Study Documents Questionnaires,	Data Collection Form	24 th January, 2019
Number of participants approved for study	-	24 th January, 2019

Specific conditions will apply to this approval. As Principal Investigator it is your responsibility to ensure that the contents of this letter are adhered to. If these are not adhered to, the approval may be suspended. Should the study be suspended, study sponsors and other regulatory authorities will be informed.

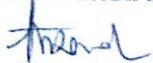
Conditions of Approval

- No participant may be involved in any study procedure prior to the study approval or after the expiration date.
- All unanticipated or Serious Adverse Events (SAEs) must be reported to the IRB within 5 days.
- All protocol modifications must be IRB approved prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address.
- All protocol deviations must be reported to the IRB within 5 working days.
- All recruitment materials must be approved by the IRB prior to being used.
- Principal investigators are responsible for initiating Continuing Review proceedings. Documents must be received by the IRB at least 30 days before the expiry date. This is for the purpose of facilitating the review process. Any documents received less than 30 days before expiry will be labelled "late submissions" and will incur a penalty.
- Every 6 (six) months a progress report form supplied by ERES IRB must be filled in and submitted to us.
- ERES Converge IRB does not "stamp" approval letters, consent forms or study documents unless requested for in writing. This is because the approval letter clearly indicates the documents approved by the IRB as well as other elements and conditions of approval.
- Every 6 (six) months a progress report form supplied by ERES IRB must be filled in and submitted to us. Late submission of these will attract a penalty.

Should you have any questions regarding anything indicated in this letter, please do not hesitate to get in touch with us at the above indicated address.

On behalf of ERES Converge IRB, we would like to wish you all the success as you carry out your study.

Yours faithfully,
ERES CONVERGE IRB



Prof. E. Munalula-Nkandu
BSc (Hons), MSc, MA Bioethics, PgD R/Ethics, PhD
CHAIRPERSON

APPENDIX 3: Letter of permission and approval to conduct research at UTH



THE UNIVERSITY OF ZAMBIA
SCHOOL OF MEDICINE



To: Dr Clarence Chiluba
Senior Medical Superintendent
University Teaching Hospital-Adult
Lusaka

6 November 2017

Subject: Request for Mr Isaac Sing`ombe to undertake an MSc Research Project to be conducted at the University Teaching Hospital.

No objection
DCh
07/11/17

Reference: Variations of the Cystic artery in cadavers

Dear Dr Chiluba

I would like to introduce Mr Isaac Sing`ombe who is an MSc Anatomy student in the University of Zambia. In order for him to undertake the research project, we require access to cadavers in the Department of Pathology.

We request permission for Mr Sing`ombe to undertake the necessary work in your hospital.

A formal request has been addressed to the Head of the Department of Pathology

We look forward to a favourable response to this request.

Yours Sincerely

Professor Krikor Erzingatsian Hon FRCSI; Hon FCS(ECSA)
MSc Anatomy Coordinator
Professor of Surgery, UNZA

APPENDIX 4: Information Sheet for Relatives

INFORMATION SHEET FOR RELATIVES

Study Title: A Cadaveric Study of the Variations of the Cystic Artery in a Zambian Population

Information sheet

I, **Isaac Sing'ombe**, the principal researcher, invites you to allow the body of your relative to participate in a study that is designed to explore the variations of the cystic artery in cadavers. Some previous studies have shown variations of the cystic artery but none of these studies have been done in Zambia. Therefore, in this study we want to estimate the length and establish the course and origin of the cystic artery and relationship between the cystic artery and bile duct. Results of this study will help surgeons know the variations of the cystic artery that are prevailing in the Zambian population to prevent complications during Cholecystectomy.

What are we asking you to do?

If you are agreeing to allow the body to participate in this study, we will incise the body from the symphysis menti up to the symphysis pubis using a blade through the midline which will expose the abdominal structure and then later on dissect the sub-hepatic region to expose the cystic artery. There is no pain and the whole procedure will take 20 minutes.

What are we going to do with the region to be dissected?

The structures that will be dissected in the abdomen will be observed, measured and photographed to establish the length, origin and course of the cystic artery.

Confidentiality

The results of all the study will be kept confidential. All information obtained in this study will be considered confidential and used only for research purposes. No one will be allowed to access

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25 JAN 2013
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PIBAG 125, LUSAKA.

any information related to the body (Cadaver). All details of the body will be recorded on a form, kept secure and no name will be included only the study number.

Right to Refuse or Withdraw

The participation of your relative's body in the study is entirely voluntary, and you are free to refuse or withdraw the body at any time without affecting or jeopardizing your future medical care.

Contact details of the Principal investigator:

Your name: Isaac Sing'ombe

Department of Anatomy, University of Zambia School of Medicine, UTH, Nationalist Rd P.O.
BOX 50398, Lusaka, Zambia (Phone 0977724193)

Contact details of Research Ethics Committee:

The Chairperson

ERES Converge IRB
33 Joseph Mwila Road
Rhodes Park
Lusaka
Tel: 0955155633/4

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APPENDIX 5: Consent Form

CONSENT FORM

Study Title: A Cadaveric Study of the Variations of the Cystic Artery in a Zambian Population

Consent record form (To be kept by Researcher)

I confirm that I have read and fully understood the information I have been presented with about the whole study. I agree that the body of my relative is used in the study and I confirm that it is out of my free will without being influenced that the body of my relative is used in the study. I can withdraw the body at any time I feel like without affecting my rights of medical care available to me. I understand what will be required of the body.

Name:

Signed (or thumbprint)

Date:

Signature (or thumbprint) of witness

Name:

Date:

I, the member of the study team, I confirm that I have explained the information fully and answered any questions

Signed for the study team

Name:

Date:

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APPENDIX 6: Data Collection Form

**DATA COLLECTION FORM
A CADAVARIC STUDY OF THE VARIATIONS OF THE CYSTIC ARTERY IN A
ZAMBIAN POPULATION**

DATE OF COLLECTION:

STUDY NO:

SERIAL NO:

INSTRUCTIONS: indicate clearly by writing in the boxes provided below

Table 1: Demographic Data and Cystic Artery Data

Demographic Data				Course of CA		Length of CA			Origin of CA						
S/N	Gen der	Age	Race	Within Calot's Triangle	Outside Calot's Triangle	2-4cm	2-4cm	2-4cm	No CA	RIA	LHA	SMA	Liver	Pancreas	Others
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															

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Table 2: Relationship between Cystic Artery and Cystic Duct

S/N	Cystic Artery anterior to the cystic duct	Cystic Artery posterior to the cystic Duct	Cystic Artery supero-medial to the cystic duct	No Cystic Artery
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

APPENDIX 7: Dissection instruments and Digital Vernier Caliper: used to measure the length of the Cystic artery

