2020-6

The Prevalence of Abdominal Aortic Aneurysm Found During Screening of a High-Risk Cardiovascular Population

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June 2020

Abstract

Introduction: The effectiveness of screening for abdominal aortic aneurysms (AAA) has been debated for many years. An AAA is defined as a focal dilation of the abdominal aortic artery exceeding 1.5 times its normal size (Kent, 2014). Risk factors associated with AAA are similar to those of peripheral vascular disease, thus the population attending a vascular laboratory are ideal candidates for AAA screening. AAAs are more common in males, in smokers, with increasing age, and more likely with a family history of AAA (Chaikof et al, 2009). Currently the UK National Screening Committee recommend one time AAA screening by ultrasound for all men 65 years of age (Davis et al, 2013). Ultrasound has a diagnostic sensitivity and specificity close to 100% and is a cheap, non-invasive means of identifying AAAs (Chun et al, 2013). The aim of this study is to determine the prevalence of AAA in patients in a high-risk population attending an Irish vascular laboratory; and to determine if the current AAA screening criteria needs modification.

Method: This is a retrospective audit of the AAA screening program performed on patients ≥60 years who attended the Mater Misericordiae University Hospital (MMUH) vascular laboratory between 1st January 2010 and 31st December 2016. A list of all abdominal aorta duplex studies carried out in this timeframe was obtained. All patients with known AAA, previous AAA surgery or patients referred for AAA screening were excluded. All remaining studies were performed for the purpose of AAA screening. Each report was reviewed and the presence or absence of AAA was documented. All necessary data was compiled in a Microsoft Excel spreadsheet and analysed.

Results: 13,565 abdominal aortic duplex studies were performed, of which 5,422 were performed for the purpose of AAA screening. Of these, 60% (3,261) were male with a mean age of 72±7.7 years; and 40% (2,161) were female with a mean age of 74±8.1 years ($p<0.001$). The overall prevalence of AAA was 6.1% (328). Of these, 79% (260) were male with a mean age of 74±7.4 years; and 21% (68) were female with a mean age of 78±7.6 years ($p<0.001$). Only 4 AAAs were detected in females aged between 60 and 64, all of which were ≤3.3cm ($p=0.08$).

Conclusion: The prevalence of AAA found in this study showed the AAA screening criteria used in the MMUH is justified for males; however the screening age profile for females was increased to ≥65 years. Nationwide AAA screening in vascular laboratories should be established to reduce AAA related deaths in the Republic of Ireland.

Declaration

I certify that this thesis which I now submit for examination for the award of Master of Philosophy, is entirely my own work and has not been taken from the work of others, save to the extent that such work has been cited and acknowledged within the text of my work.

This thesis was prepared according to the regulations for postgraduate study by research of the Technological University Dublin and has not been submitted in whole or in part for another award in any institute.

The work reported on in this thesis conforms to the principles and requirements of the institutes guidelines for ethics in research.

The institute has permission to keep, lend or copy this thesis in whole or in part, on condition that any such use of the material of the thesis be duly acknowledged.

Signed: _____

Sorcha Amond Murray

Date: 09/06/2020

Acknowledgements

Firstly a huge thanks to Dr Cleona Gray for her constant support throughout my career. Thanks for the push to get this thesis underway and the continued help and encouragement throughout – you are a driving force!

Also to my TU Dublin supervisor Professor Pat Goodman, thank you for all that you've done along the way, it is greatly appreciated.

Thanks to Professor Ciaran Mc Donnell for your ever helpful input and guidance throughout this research, and most importantly for me – proof reading!

A big thank you to Professor O'Donohoe, Mr Mulkern and all the staff of the vascular laboratory in the Mater Misericordiae University Hospital for their support, especially Michelle O'Hare who has powered through this journey with me!

Thank you to my amazing family for their ever present support in all that I choose to do, and for their constant encouragement along the way.

Finally, a massive thank you to my fantastic partner Dan for all of his patience, Excel help and general support from day one with this research project. Thank you for keeping me together!

Abbreviations

AAA	Abdominal Aortic Aneurysm
ADAM	Aneurysm Detection and Management
AP	Antero-posterior
CIA	Common Iliac Artery
CT	Computed Tomography
EPR	Electronic Patient Record
ESVS	European Society for Vascular Surgery
EVAR	Endovascular Aortic Repair
IMA	Inferior Mesenteric Artery
MASS	Multicentre Aneurysm Screening Study
MMUH	Mater Misericordiae University Hospital
MRA	Magnetic Resonance Angiography
MRI	Magnetic Resonance Imaging
NAAASP	National Abdominal Aortic Aneurysm Screening Programme
OSR	Open Surgical Repair
SMA	Superior Mesenteric Artery
UKSAT	UK Small Aneurysm Trial
WHO	World Health Organisation

Table of Contents

List of Tables

List of Figures

CHAPTER I

INTRODUCTION & RATIONALE FOR THIS RESEARCH

Abdominal aortic aneurysm (AAA) is a potentially lethal condition often undiagnosed until it ruptures, producing catastrophic life-threatening haemorrhage.

An AAA is defined as a focal dilation of the abdominal aorta exceeding 1.5 times its normal size, or an infra renal diameter of greater than 3cm (Kent, 2014). Ruptured AAAs are responsible for up to 2% of all deaths in the Western world (Forsdahl et al, 2009), with the risk of rupture being proportionate to the size of the AAA. Results of elective repair are far superior to emergency surgery, thus detection in the asymptomatic stage is vital.

The benefits of screening for AAA have long been debated. Screening programmes using duplex ultrasound are now established in many countries and have been shown to reduce the mortality from ruptured AAA as well as being cost-effective (Mani et al, 2010). Ultrasound has a diagnostic sensitivity of 98% and a diagnostic specificity of 99% (Chun et al, 2013) and is considered the best method for AAA screening and surveillance as it is non-invasive, cost-effective and relatively quick, with test time being as short as four minutes (Lee et al, 2002). The Republic of Ireland currently does not have a national AAA screening programme.

The current recommendation by the UK National Screening Committee is to screen all men at the age of 65 years for AAA (Davis et al, 2013). This is based on the Multicentre Aneurysm Screening Study (MASS) which demonstrated that a single abdominal ultrasound performed within this group significantly reduces the rate of premature death from AAA rupture. It is also recommended to screen women aged 60 to 85 years with

cardiovascular risk factors; and both men and women greater than 50 years of age with a family history of AAA (Kent et al, 2004). Based on a combination of these recommendations an AAA screening programme has been available to all patients both male and female 60 years of age and over who attend the vascular laboratory in the Mater Misericordiae University Hospital (MMUH) for non-invasive arterial studies since January 2010.

This study is a retrospective clinical audit of the current AAA screening programme in the MMUH which includes a cardiovascular population of patients 60 years of age and over who received an abdominal aorta duplex study for the purpose of AAA screening while attending MMUH vascular laboratory between 1st January 2010 and 31st December 2016.

The aims of this study are to;

- Determine the prevalence of AAA in a high-risk cardiovascular population being investigated for vascular disease.
- Determine if the current AAA screening criteria needs to be modified accordingly to refine the population being referred to the vascular laboratory, thus better utilising resources.

CHAPTER II

ANATOMY & PHYSIOLOGY OF ABDOMINAL AORTIC ANEURYSMS

2.1 The Aorta

2.1.1 Introduction

The aorta is the largest artery in the body that delivers oxygenated blood to all of the organs and tissues. It arises from the left ventricle of the heart, ascending and arching to the left, then descending through the thorax and passing into the abdomen.

The aorta comprises of three segments; the ascending aorta, the arch of the aorta and the descending aorta (figure 2.1). The descending aorta is sub-divided into two segments; the thoracic aorta and the abdominal aorta, based on the location.

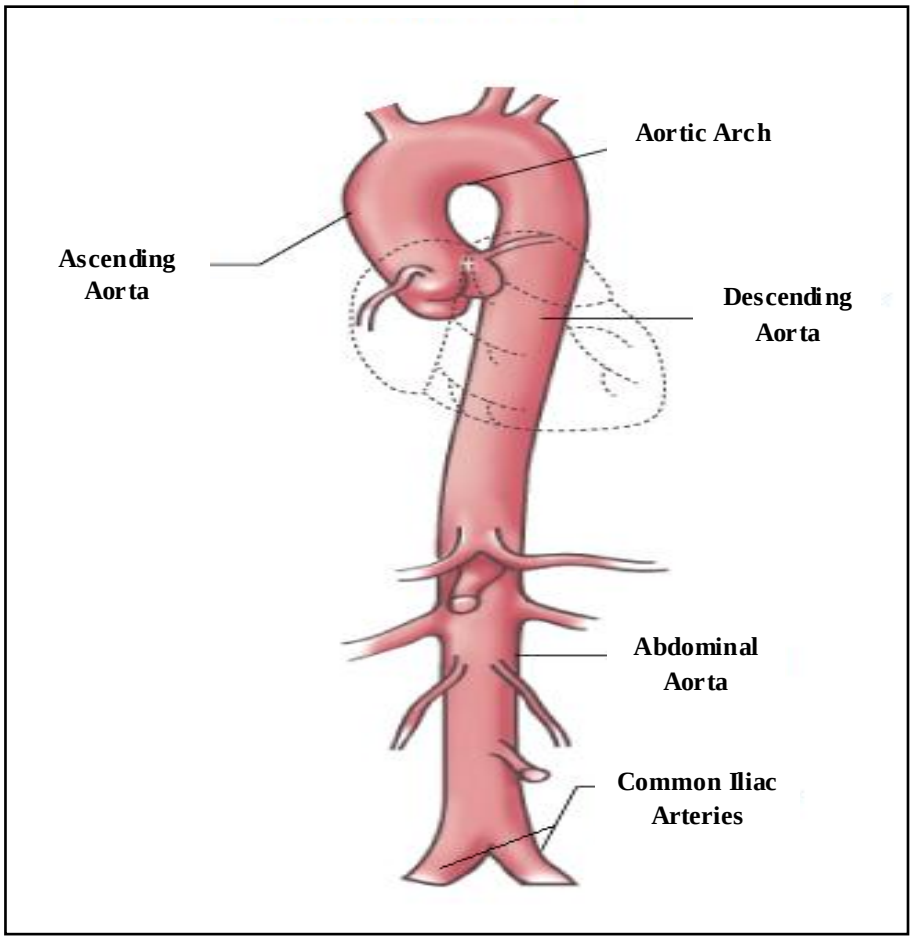

Figure 2.1 The Aorta[1]

The abdominal aorta continues inferiorly until it bifurcates at the level of the fourth lumbar vertebrae into the right and left common iliac arteries (CIA). Each CIA divides into the internal and external common iliac arteries (figure 2.2). The internal iliac arteries supply the pelvis, the buttock and the reproductive organs. The external iliac arteries travel inferiorly, supplying the lower limbs, becoming the common femoral arteries at the level of the inguinal ligament in the groin.

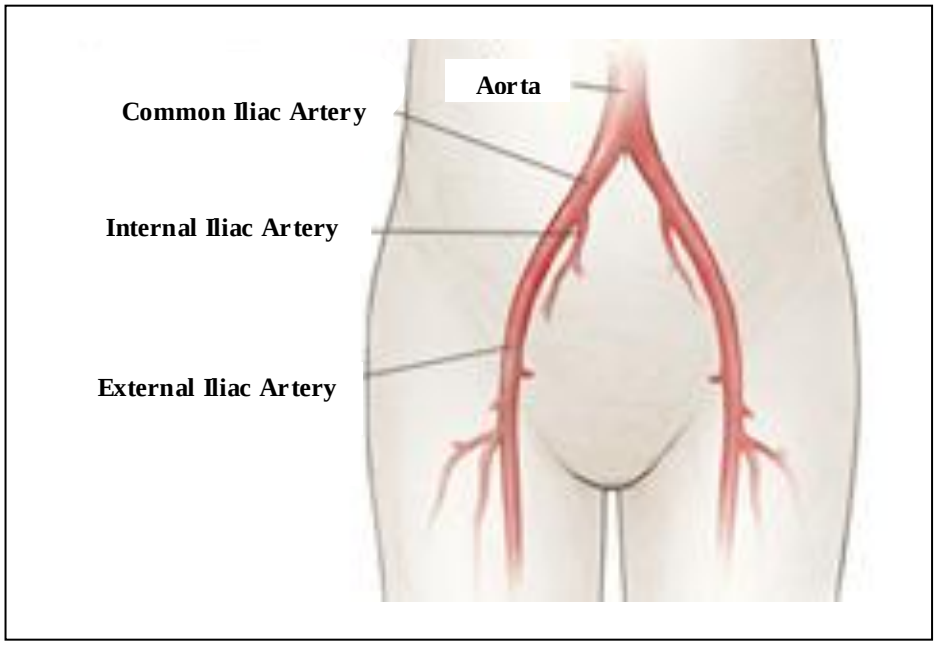

Figure 2.2 The Iliac Arteries[2]

2.1.2 Branches of the Aorta

Multiple branches arise from the abdominal aorta (figure 2.3), some of which are an important reference point when dealing with abdominal aortic aneurysms. The first branch is the coeliac trunk, which is the common origin of the common hepatic artery (supplying the liver), the splenic artery (supplying the spleen) and the left gastric artery (supplying the stomach). Just below the coeliac trunk is the superior mesenteric artery (SMA), which supplies multiple regions of the digestive system.

The most commonly referenced branches when referring to abdominal aortic aneurysms are the next pair of arteries arising from the aorta - the right and left renal arteries, which supply the kidneys. After these comes the inferior mesenteric artery (IMA), which supplies the lower intestine. Finally, multiple pairs of lumbar arteries arise from the posterior aspect of the abdominal aorta to perfuse the musculature of the back and sometimes augmenting the blood supply of the spinal cord.

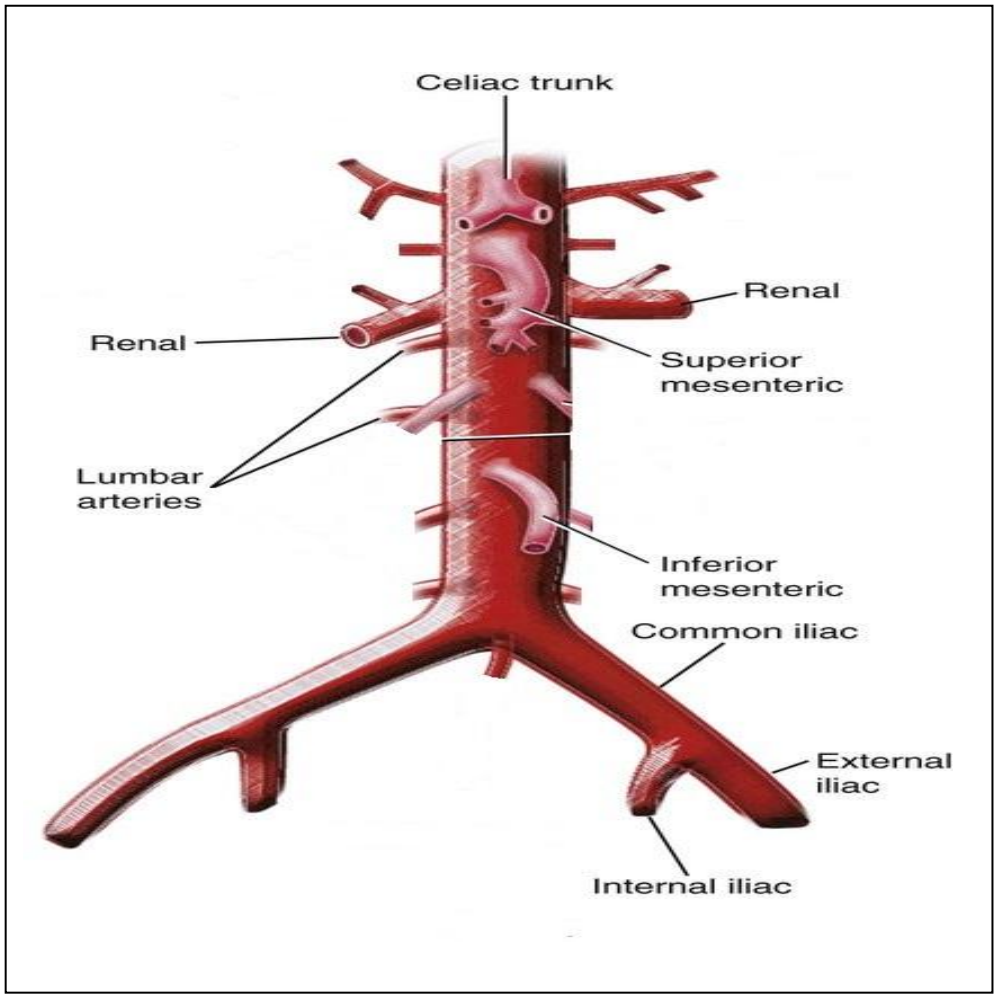

Figure 2.3 Branches of the Aorta[3]

2.2 Abdominal Aortic Aneurysm

2.2.1 Introduction

The arterial wall comprises three distinct layers; the intima, the media and the adventitia. Dilation of the artery occurs when the composition of the wall itself alters, producing a weakened vessel wall and an inability to hold its structure. When a vessel diameter exceeds 1.5 times its normal size, it is considered aneurysmal. In the case of the abdominal aorta, the normal diameter is documented as 2.0-2.4cm in males and 1.6cm-2.2cm in females (Donnelly et al, 2009). Therefore once the aorta dilates to or above 3cm in diameter it is considered aneurysmal in the majority of cases. Exception can occur in the case of those with arteriomegaly; a term used to define a generalised enlargement of the entire arterial system which does not imply aneurysm formation (Belardi et al, 1999).

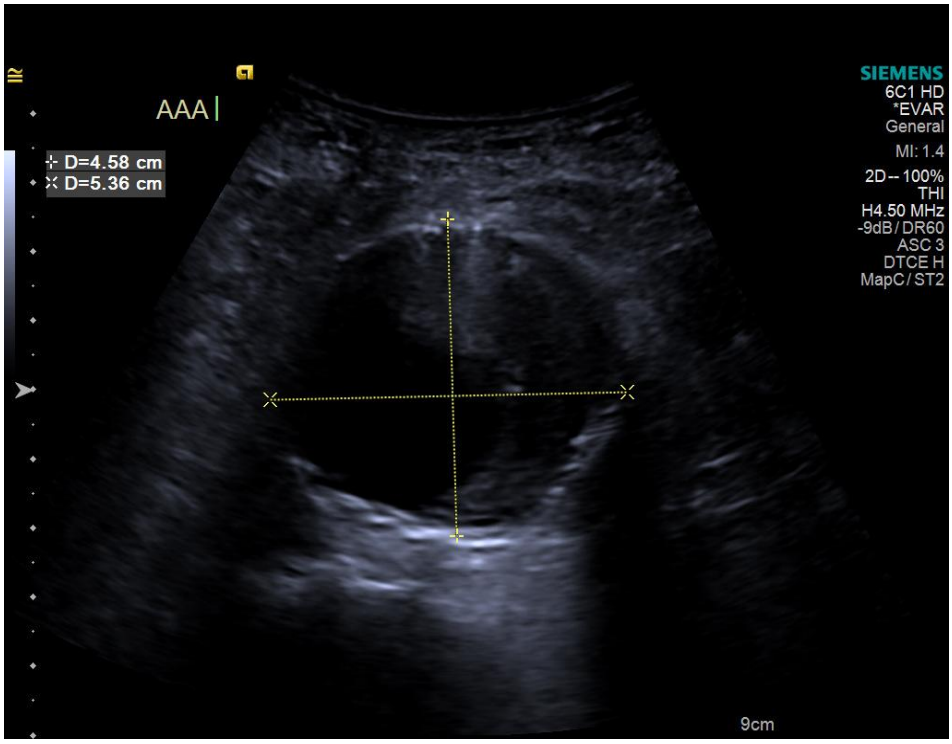

Figure 2.4 Duplex Image of Large AAA[4]

2.2.2 Classification of Abdominal Aortic Aneurysms

Aneurysms may be classified as either true or false (figure 2.5). A true aneurysm involves all three layers of the arterial wall. A false aneurysm, also known as a pseudoaneurysm, occurs when the layers of the wall are damaged; allowing blood to leak out through the wall but remaining contained by either the adventitia layer of the artery, or by the surrounding soft tissue. Such damage can be caused by trauma to the vessel, infection or during surgery (Atik et al, 2006). Pseudoaneurysms have a high-risk of rupture due to poor wall tensile strength, and generally require urgent treatment.

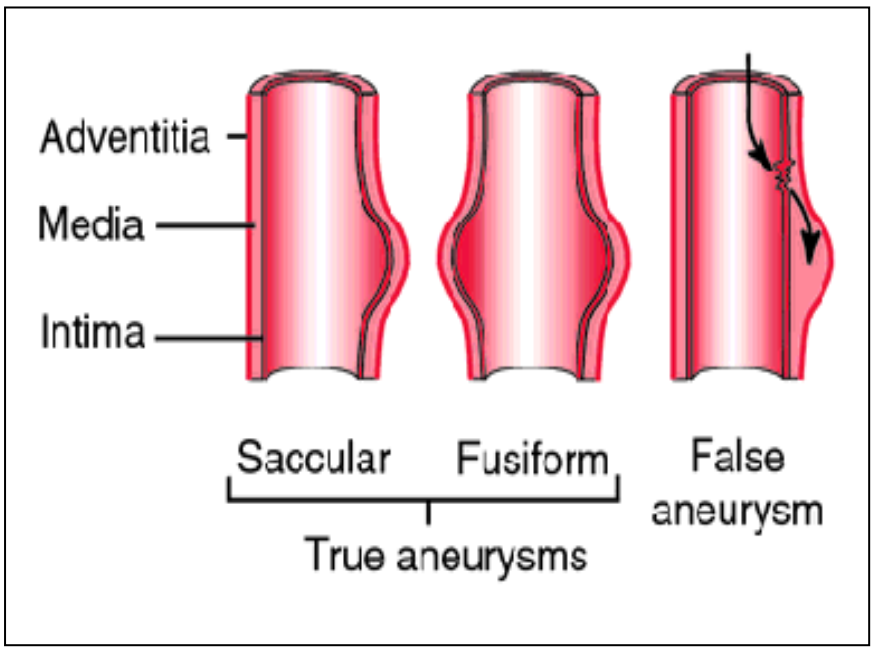

Figure 2.5 True vs False Aneurysms[5]

The more commonly occurring aneurysms are true aneurysms, the commonest of these being an abdominal aortic aneurysm (AAA). An AAA can be described as a supra-, juxta- or an infra-renal AAA, depending on its relationship with the renal arteries (figure 2.6).

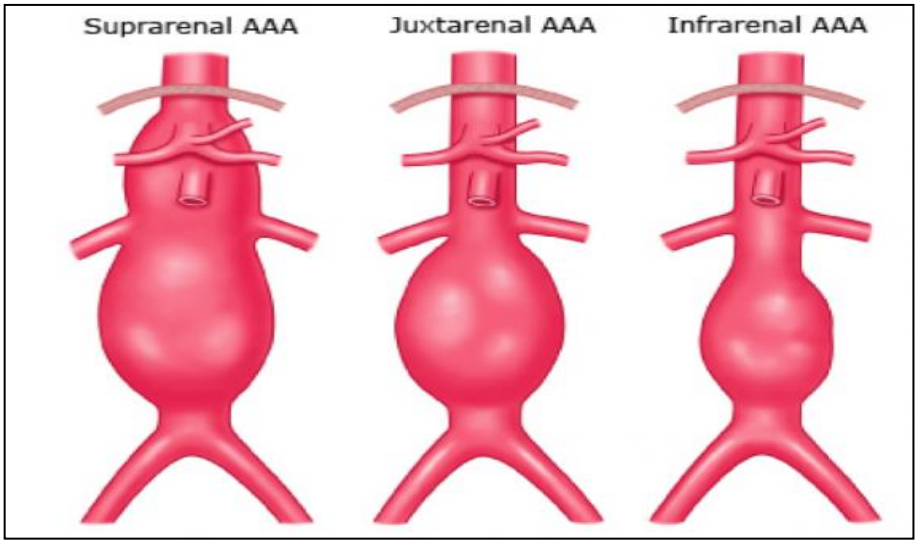

Figure 2.6 AAA relationship to the Renal Arteries[6]

An AAA can also be classified by its shape which is typically fusiform, but they can also be saccular (figure 2.7, figure 2.8). Some AAAs have two regions of dilatation along the vessel, resulting in a dumbbell appearance.

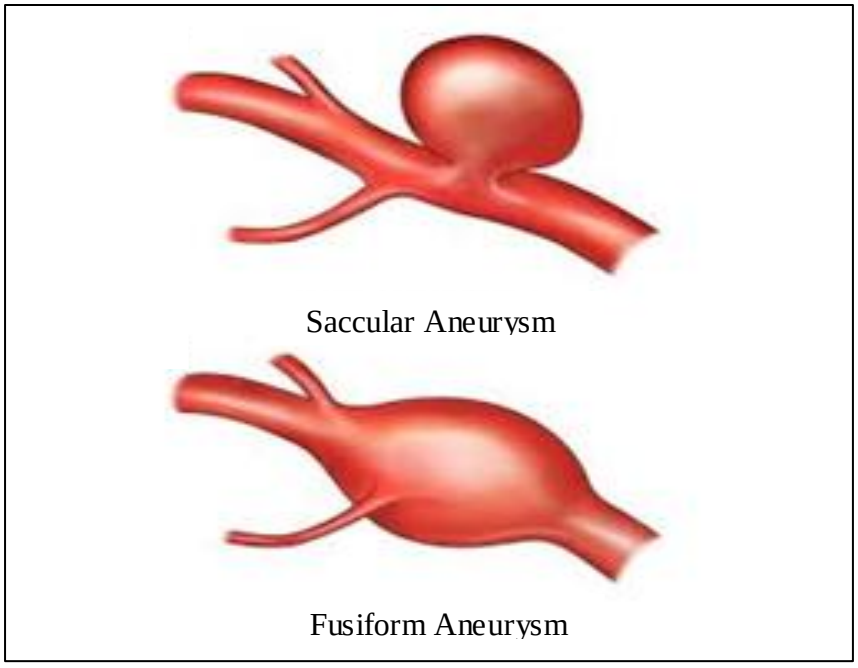

Figure 2.7 Shape of Aneurysm[7]

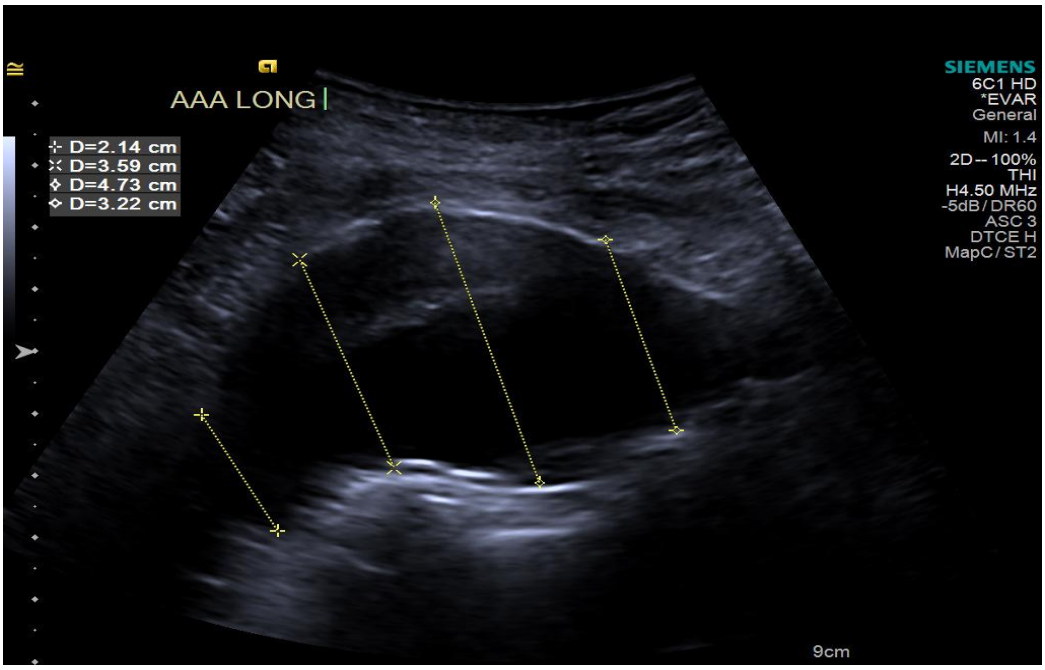

Figure 2.8 Duplex Image of Fusiform AAA[8]

2.2.3 Risk Factors

Aneurysm formation is multi-factorial, with multiple risk factors thought to contribute. Smoking is an important risk factor in aneurysm formation, with the duration of smoking more relevant than volume of nicotine exposure (Chaikof et al, 2009). Male gender increases the risk of AAA formation four to six-fold. The risk of AAAs formation increases in direct proportion to increasing age (Aggarwal et al, 2011). Family history of AAA is a major risk factor as they are often hereditary, especially in male descendants. Atherosclerotic diseases, obesity, hypertension, hyperlipidaemia, infection and connective tissue disorders are also documented risk factors for AAA (Gray et al, 2011).

2.2.4 Symptoms of AAA

Approximately 90% of AAAs are asymptomatic. For the few that do present with symptomatic AAAs, signs may include a pulsatile abdominal mass, abdominal pain or back pain. AAAs may also present as 'blue toe syndrome'; a form of acute distal ischemia. At the level of aneurysmal dilatation, blood flow can become turbulent, slowed and often stagnant in the areas closer to the aneurysm walls (figure 2.4). This allows the small particles within the blood to stick to the damaged artery walls and build up as thrombus (Wilson et al, 2013). As the remaining blood continues to travel through the AAA, small pieces of unstable thrombus, called emboli, can become detached and travel down the blood stream, eventually getting lodged in the smaller arteries in the foot or toes. This process can cause a sudden lack of oxygen to the area being supplied resulting in acute distal ischemia.

However, the majority of patients with an AAA remain asymptomatic until the onset of rupture. In the case of rupture, the patient may present with severe abdominal or back pain, low blood pressure, a pulsatile abdomen, dizziness, nausea and vomiting. Rupture of an AAA results in the complete loss of aortic wall integrity and is considered a surgical emergency which needs immediate repair. AAA rupture results in an overall mortality rate of 90% (Assar et al, 2009).

CHAPTER III

DIAGNOSIS & CLINICAL MANAGEMENT OF ABDOMINAL AORTIC ANEURYSMS

3.1 Diagnosis

An AAA can be diagnosed during physical examination of the abdomen. A pulsatile mass may be felt, or in very thin patients, seen in the centre of the abdomen. Should this preliminary diagnosis occur, further diagnostic imaging is warranted to confirm the finding.

AAA can be diagnosed with multiple invasive and non-invasive imaging modalities such as magnetic resonance angiography (MRA), computed tomography (CT) and X-ray however ultrasound is found to be the preferred method as it is readily available and non-invasive, with a specificity and sensitivity of almost 100% (Chun et al, 2013). Ultrasound is the diagnostic tool of choice in AAA screening programs where a skilled operator can quickly and easily identify the presence of AAA. Ultrasound is considered the gold standard for AAA screening according to a recent article by Siso´-Almirall et al (2017). As it can be portable, ultrasound allows for the possibility of AAA screening programmes within the community. Ultrasound is not without its limitations. Scans can often be inconclusive due to the patients' body habitus, when obesity can result in the aorta being too deep to image adequately; or due to overlying bowel gas which can obscure the aorta from view, as ultrasound waves cannot travel through air.

3.2 Treatment

3.2.1 Surveillance & Risk Factor Modification

Once an AAA is diagnosed, the patient should be seen at a vascular outpatient clinic where they can be assessed by the vascular team to establish any risk factors associated with AAA they might have. By applying best medical therapy for these risk factors, such as smoking cessation and improving cholesterol levels using statins, the patient has a better chance of reducing their risk of mortality (Golledge et al, 2007; Kurosawa et al, 2013).

The discovery of an aneurysm at an early stage means that a patient can be entered into a properly monitored surveillance programme and observed closely for growth of the AAA, allowing consideration for repair of the aneurysm at the correct stage. Ultrasound is not only the best imaging modality for AAA screening; it is also the safest and most cost-efficient method of regular AAA surveillance (Lee et al, 2002).

An algorithm, such as the one used in the MMUH vascular laboratory which is outlined in figure 3.1, should be followed to determine whether the next step for the patient is discharge, surveillance and risk factor modification or intervention.

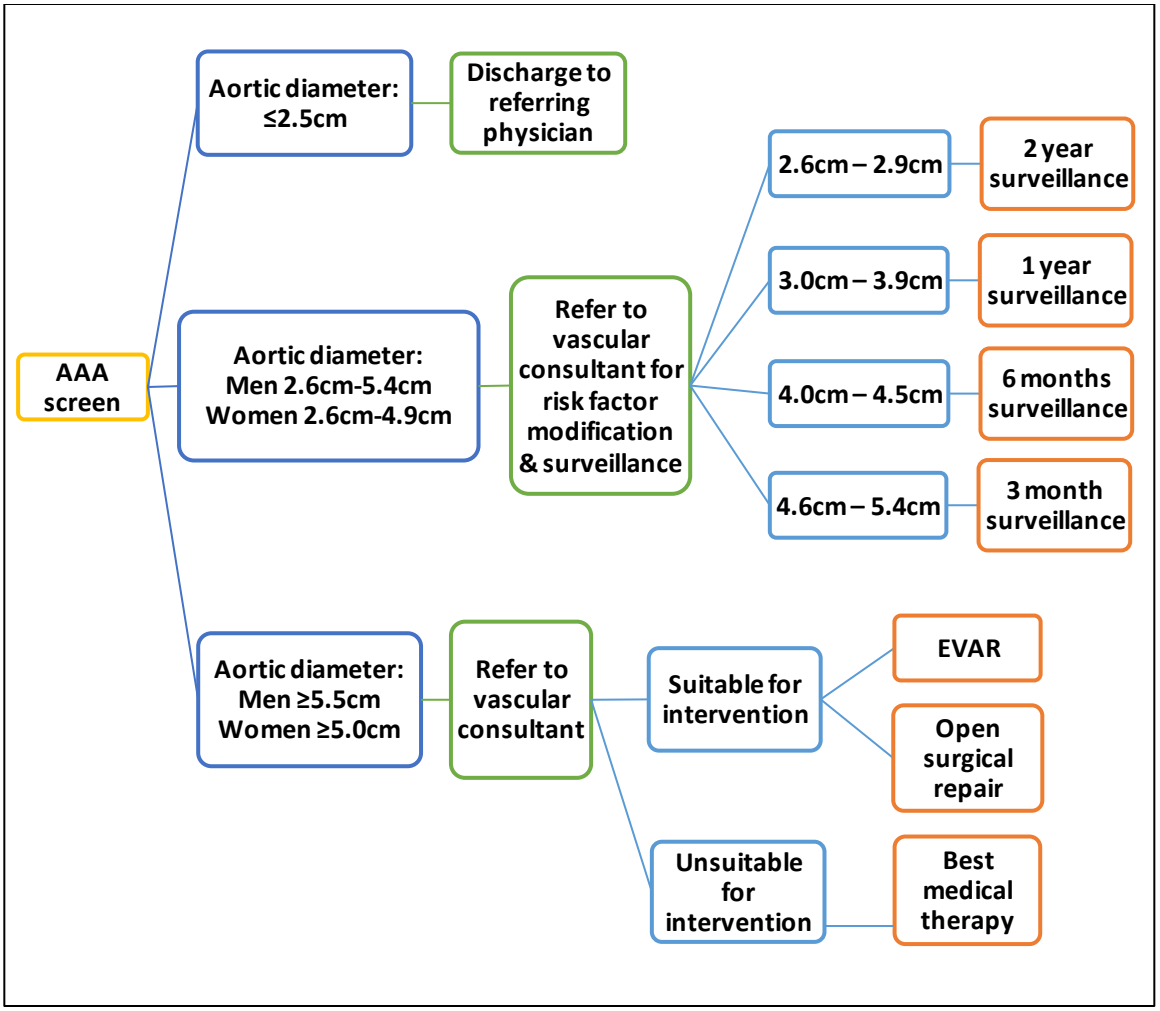

Figure 3.1 AAA Screen Algorithm[9]

3.2.2 AAA Intervention & Repair

As AAA rupture carries a 90% mortality rate, the main goal of AAA management is to prevent rupture from occurring. If an AAA is found to be equal to or greater than 5.0cm in women, or 5.5cm in men on screening, the patient should be referred to a vascular consultant for consideration for elective repair. AAA repair may also be considered if the AAA becomes symptomatic before reaching the recommended thresholds, such as sharp abdominal or back pain; or there is a significant increase in diameter between visits (greater than 1cm per year).

The principle behind any AAA repair procedure is to prevent the aneurysm form rupturing by excluding it from the systemic circulation. There are currently two treatment options:

- Open surgical repair
- Endovascular aneurysm repair

Before deciding which treatment option will be performed, the patient must undergo multiple pre-op assessment studies including blood tests and a CT Aorta, to assess the patient's suitability for surgery and to examine the morphology of the aneurysm and the relationship of the AAA to the renal arteries which can determine the surgical option used. The presence of other co-morbidities is also considered and can influence the decision whether or not to proceed with surgery.

3.3 AAA Open Surgical Repair

Open surgical repair (OSR) was for many years the method of choice for AAA repair. The abdominal cavity is entered via an abdominal incision (laparotomy). The intra-abdominal contents are moved to the side of the abdomen to expose the aorta. Clamps are placed on the proximal aorta and on each iliac artery to arrest blood flowing through the aneurysm and to minimise the risk of distal embolisation. The aneurysm sac is dissected longitudinally and any thrombus that is present is removed. If the aneurysm involves the iliac arteries, the dissection must extend to the bifurcation of the common iliac arteries.

A prosthetic graft is then chosen and sewn onto the normal portions of the artery above and below the AAA, essentially replacing the aneurysm (figure 3.2). Any remaining debris is flushed from the graft and it is filled with diluted heparinised saline solution. The clamps are then removed and the aneurysm sac is closed around the graft to act as protection around the graft from contact with the intra-abdominal contents. Finally the bowel is checked for ischaemia and placed back in its normal position and the abdomen is closed.

OSR typically necessitates a seven to ten day hospital stay postoperatively. OSR has proven to be a more durable method of treatment as it does not require life-long follow-up (Upchurch et al, 2006). Perioperative complications include myocardial infarction, congestive heart failure, acute renal failure, lower limb ischemia, respiratory failure, mesenteric ischaemia, and spinal cord infarction amongst others.

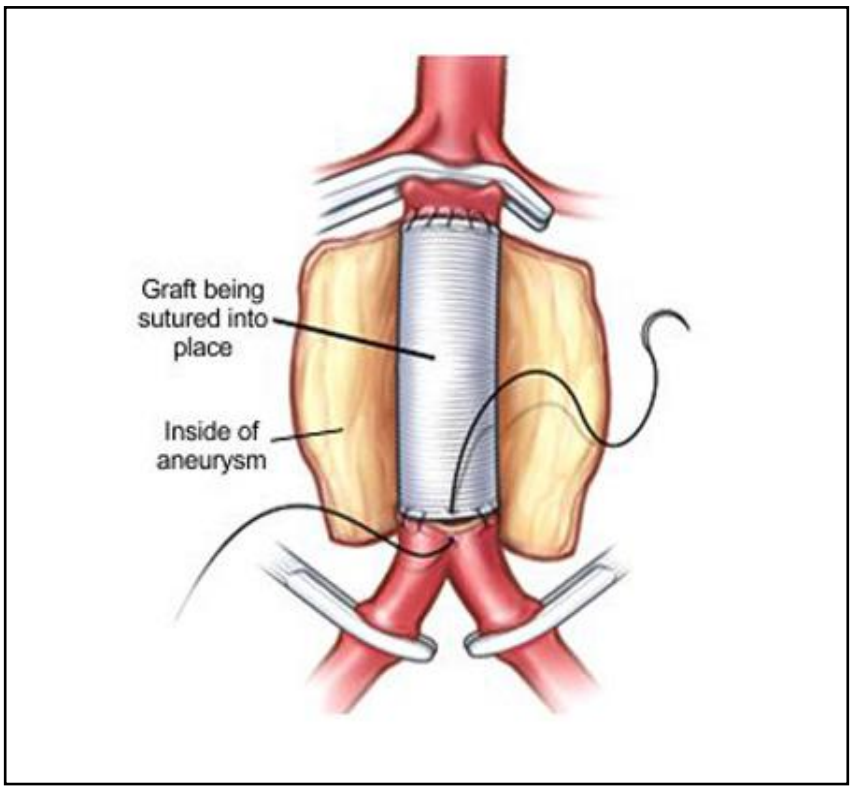

Figure 3.2 Open AAA Repair[10]

3.4 Endovascular Aneurysm Repair

3.4.1 Introduction

Since 1990 endovascular aneurysm repair (EVAR) has been employed as a less-invasive alternative to open AAA repair. Similar to open surgical repair, EVAR involves placing a prosthetic graft within the aneurysm to exclude it from the systemic circulation. The endograft has an expandable metal frame to hold it in place and provide a seal proximal and distal to the aneurysm (figure 3.3). When the graft is fixed in place it permits flow through the graft, therefore excluding the aneurysm from the systemic circulation.

Unlike the invasive incision that is required for OSR, EVAR is performed via two small incisions in both groins, as opposed to the laparotomy and aortic clamping associated with open repair (figure 3.4). The lesser surgical insult associated with EVAR lead to a reduction in post-operative hospital stay and a more rapid recovery once discharged. Multiple studies have shown a lower 30 day post-operative mortality in comparison to open AAA repair. However, EVAR is not without complications including graft infection, graft migration, ischemic changes due to embolisation or covering of an aortic branch, stenosis or occlusion of a graft limb and endoleaks.

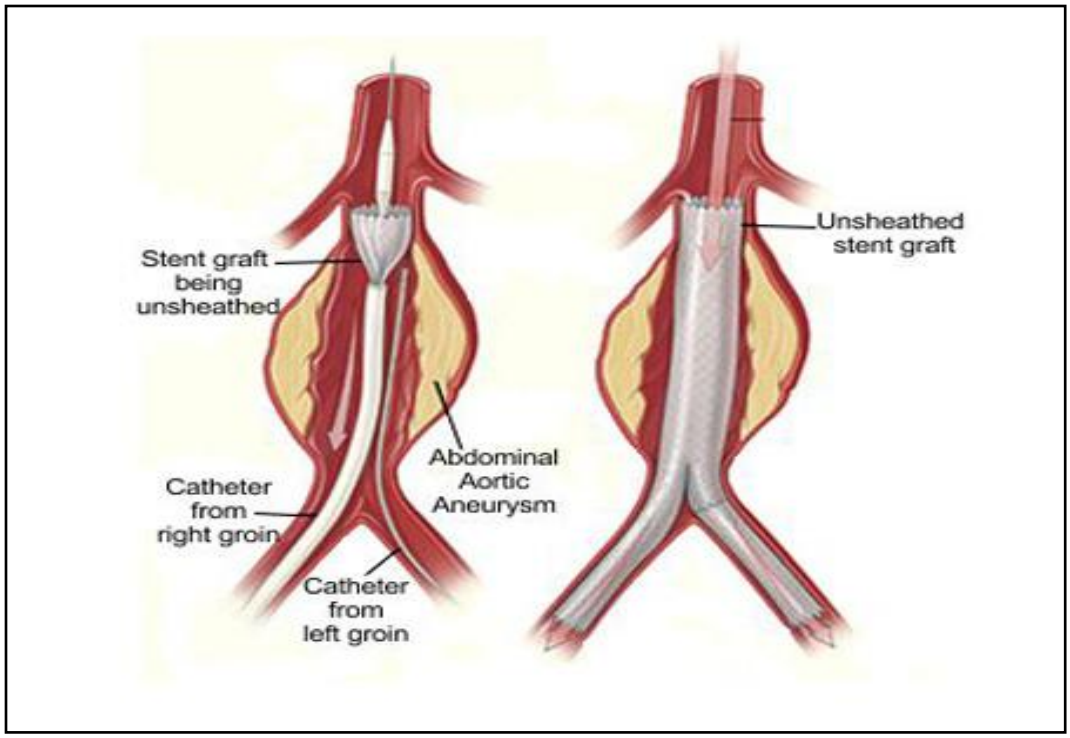

Figure 3.3 Endovascular Aneurysm Repair[11]

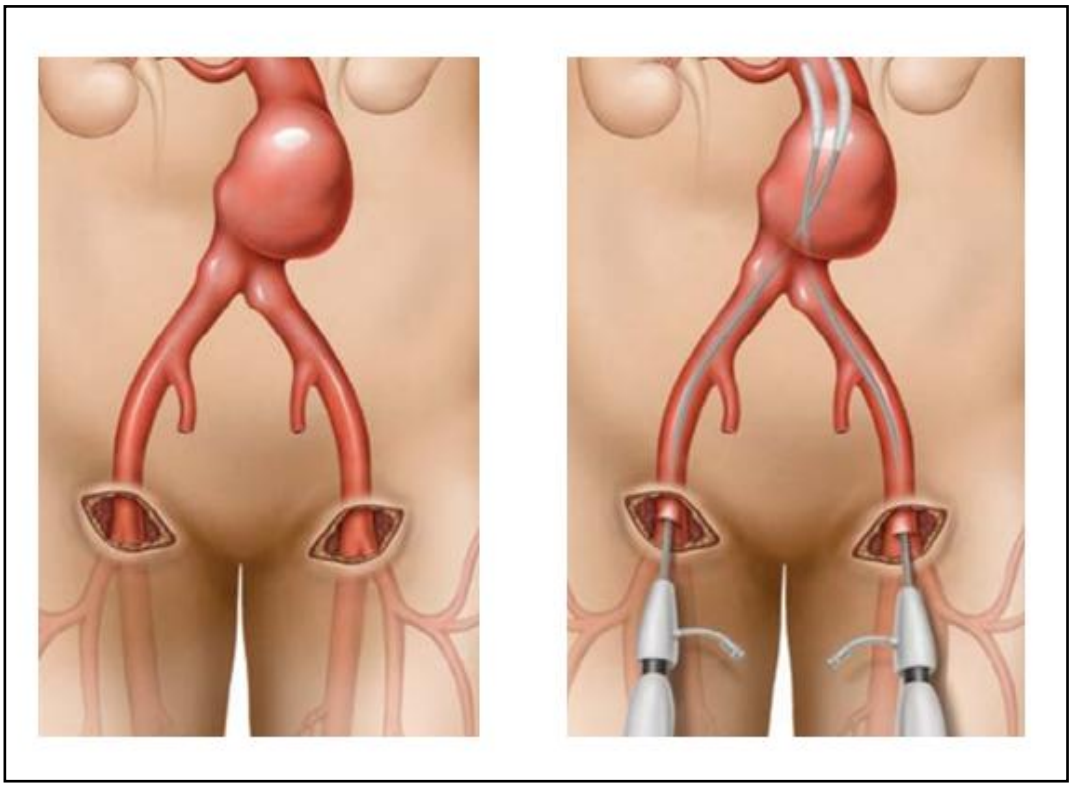

Figure 3.4 Groin Incisions & Catheter Insertion[12]

3.4.2 Endoleaks

Due to a complication referred to as an endoleak, EVAR patients require life-long follow up. Endoleaks are defined as the persistence of flow outside the endograft and within the aneurysm sac. As the aneurysm sac is not completely excluded from the systemic circulation it may still be at risk of rupture. Endoleaks are classified into one of four types depending on the origin of the leak:

- Type I Endoleak – An inadequate proximal (type I A) or distal (type I B) sealing of the endograft to the native vessel. This type of endoleak usually results in high velocity blood flow still circulating within the residual aneurysm sac, increasing the risk of rapid sac growth and rupture. Type I endoleaks need urgent repair.
- Type II Endoleak – The presence of retrograde collateral flow into the aneurysm sac from a branch of the abdominal aorta, usually the IMA or a lumbar artery. A type II A endoleak has a single feeding vessel whereas the presence of two or more vessels is sub-classified as a type II B endoleak. Type II endoleaks are usually monitored closely to assess their impact on the residual aneurysm sac. If there is no increase in sac size observed they are usually managed conservatively, however should the sac size increase further intervention such as embolisation of the feeder vessel is required.
- Type III Endoleak – This occurs when a leak occurs through a defect in the endograft. A type III A endoleak is when an endograft limb detaches from the main body of the endograft. A type III B occurs if there is a fracture or hole in the endograft. As with a type I endoleak, a type III endoleak results in high velocity blood flow circulating within the aneurysm sac, increasing the risk of rapid sac growth and rupture, and therefore requires urgent repair.

- Type IV Endoleak – A rare type of endoleak that involves the porosity of the graft material itself.

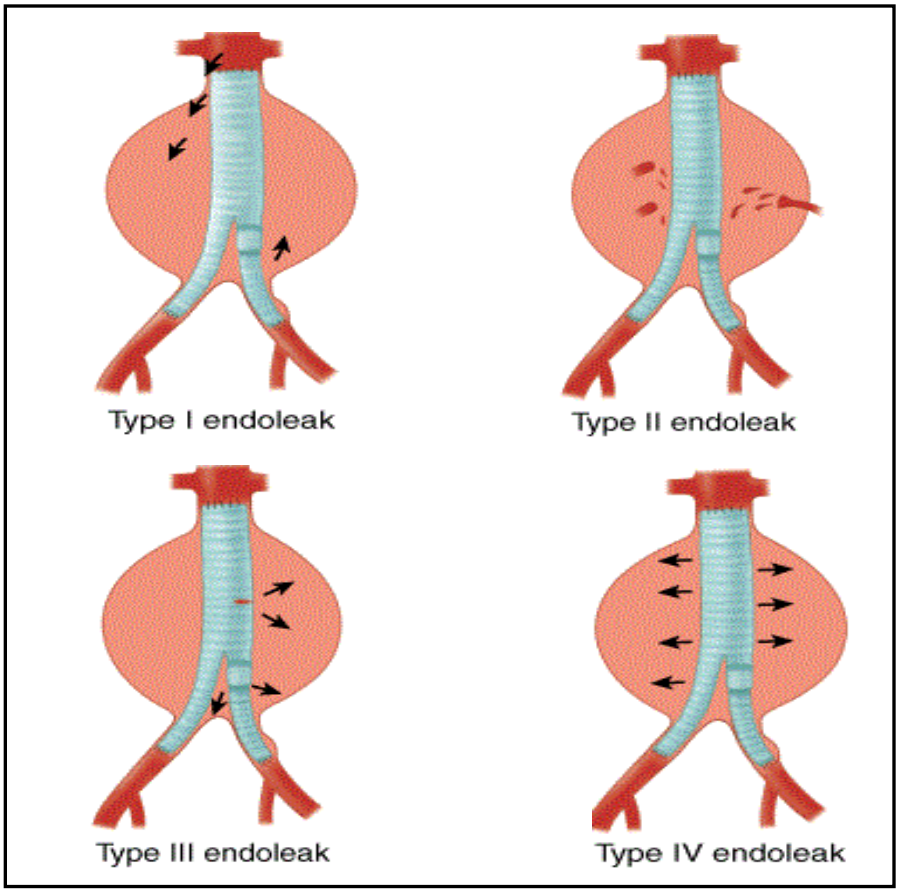

Figure 3.5 Types of Endoleak[13]

"Endotension" is sometimes considered a fifth type of endoleak. It is a state of elevated pressure within the aneurysm sac, causing expansion of the aneurysm sac without the presence of a documented endoleak on any imaging modality.

CHAPTER IV

LITERATURE REVIEW OF ABDOMINAL AORTIC ANEURYSM SCREENING

4.1 Prevalence of Abdominal Aortic Aneurysms

Prevalence rates for AAA vary depending on the definition employed. Depending on the diagnostic criteria used, AAA prevalence varied in the existing literature from 3.6% to 16.9% in males, and from 0.8% to 9.4% in females (Wanhainen, 2004). Wanhainen's study also showed that the greatest detection rates were found using different criteria for males and females, with a maximum aortic diameter of greater than or equal to 3cm on ultrasound resulting in the highest detected rates in males (16.9%), and a maximum aortic diameter greater than or equal to 1.5 times the normal infra renal abdominal aortic diameter on ultrasound resulting in the highest detected rates in females (9.4%). Thus a fixed diameter appears to be an appropriate definition for males, but may underestimate the presence of AAA in females. Despite this, a fixed diameter of greater than or equal to 3cm is the most widely accepted definition of AAA, and is the definition employed in this study.

One of the largest AAA screening studies performed on the general population in the UK to date is the MASS, a randomised trial by Ashton et al (2002). This study included 27,147 subjects; all of whom were males; and reported a prevalence of AAA of 4.9%. The Aneurysm Detection and Management (ADAM) screening programme - a large US based screening study - included 52,745 veterans; both male and female; and yielded a prevalence of 3.6% (Lederle et al, 2000). A more recent screening programme in Northern Ireland included 5,931 patients and resulted in a prevalence of 5.4% (Badger et al, 2011). A review of the first five years of the NHS AAA screening programme in the UK by Jacomelli et al (2016) analysed the first 700,000 men and reported an AAA prevalence of 1.3%, which is significantly lower than that found in the other studies. Each study defined an AAA as having a maximum aortic diameter ≥3.0cm.

Chaikof et al (2009) state that it is estimated that 5% to 10% of older males have an AAA, however the majority of the AAAs are small, and that the probability of AAA in the general population is very low, but is increased when certain risk factors come into play such as increasing age, smoking, family history and atherosclerotic diseases.

The occurrence of AAA is six times more common in males that in females (Ashton et al, 2002; Chaikof et al, 2009). In a study carried out by the US Preventative Services Task Force (2014) it is also agreed that the prevalence of AAA in women is approximately one sixth that of men. A study by Lederle (2008) documents similar figures, saying AAA is four to six times more common in males than females, however this study also states that despite higher prevalence of AAA in males, more than one third of all AAA deaths occur in females. It mentions in several reports from the UK Small Aneurysm Trial (UKSAT) by Cronenwett et al (1999) that the rupture rate for women was three to four times that of men. This led to the recommendation of a joint council of vascular societies that AAA should be repaired earlier in females; however the sum of evidence available provided no reason to alter the threshold of 5.5cm for women according to the Lederle study. However in 2019 the European Society for Vascular Surgery (ESVS) published updated guidelines on AAA management which recommend that the threshold for elective AAA repair in women may be 5.0cm (Wanhainen et al, 2019).

Brosnan (2011) reported an AAA prevalence of 1.9% in a population of 904 Irish males aged between 55 and 75 years. There was a prevalence of 0.6% in 55 to 65 year olds, increasing to 4.2% in 65 to 75 year olds. Brosnan's study was flawed in that only the anterior-posterior (AP) aortic wall diameter was measured compared to other major studies that measured both AP and transverse wall diameters. By omitting the transverse wall diameter the accuracy of the overall results were reduced as the transverse

diameter of an AAA can often be the larger diameter. Currently there are no statistics available regarding the prevalence of AAA in Irish females.

4.2 Rupture

Ruptured AAA is a major, life threatening condition with a grim prognosis; however, this severe condition is preceded by a long period of silent growth of the aneurysm, which may go on for more than 10 years before any clinical signs occur (Aboyans et al, 2010). The risk of AAA rupture in females is three to four times greater than in males, with rupture often occurring at a smaller AAA diameter in females (Brewster et al, 2003; Grootenboer et al, 2009). This lead Brewster et al (2003) to conclude that an AAA diameter of 5cm in a female has an equivalent risk to that of a 6cm AAA in a male. Semmens et al (2000) have also reported a higher rate of mortality in females than males due to AAA rupture, with an overall mortality rate of 90% in females compared to 76% in males. This study also noted that despite the females being on average six years older than the males, the increased mortality rates cannot be explained by greater age alone as females of all ages undergoing surgery were more likely to die than their male counterparts.

The UKSAT (Cronenwett et al, 1999) showed that the risk of rupture of AAA under surveillance that measured between 4.0cm and 5.5cm was low, at 1% per year. This trial concluded that ultrasound surveillance is safe and that proceeding to open surgical repair for AAA of this size is not necessary for the average patient in the study. In comparison, a study by Swedenborg (2008) concludes that many findings support the suggestion that some patients, particularly females, should be offered surgical

intervention once their AAA has a diameter between 5-5.5cm due to the increase risk of AAA rupture in women at 5cm.

Physical examination of a patient presenting with AAA rupture has a sensitivity of less than 65%, and almost 30% of ruptured AAA are misdiagnosed on initial presentation according to a study by Gibbons et al (2018). Less than 25% of patients with ruptured AAA present with the characteristic triad of hypotension, pulsatile abdominal mass and abdominal pain.

The incidence of rupture of AAA has a seasonal variation with a higher occurrence of rupture during the winter months (Bown et al, 2003). Rates of AAA rupture were lowest in August and highest in December which suggested that low atmospheric pressure is associated with increased rate of rupture.

4.3 Risk Factors

In the general population the overall probability of developing an AAA is low, however it is significantly increased in the presence of risk factors, such as smoking, family history of aneurysms, male gender, increasing age, hypertension, atherosclerotic diseases and hypercholesterolemia (Lederle et al, 1997; Chaikof et al, 2009; Gray et al, 2011). Badger et al (2008) state that a higher prevalence of AAA is encountered in high-risk patients, such as the patients being assessed in this study. A positive family history of AAA is one of the more significant risk factors (Chaikof et al, 2009). Of those who undergo AAA repair, 12-19% have a first degree relative with an AAA. Van de Luijtgaarden et al (2015) state that relatives of patients with AAAs are 2-3 times more likely to develop an AAA themselves in their lifetime. Screening of relatives of those with AAAs suggests a prevalence of 17% in males and 4% in females.

The risk factors associated with AAA are similar to those of peripheral vascular disease, other than the presence of diabetes. Despite being a major risk factor in peripheral vascular disease, diabetes demonstrates a protective effect on the development of AAA (Vardulaki et al, 2000; Shantikumar et al, 2010).

Smoking is the most significant risk factor associated with AAA growth, with the number of years as an active smoker appearing to be more significant, compared to the number of cigarettes smoked per day (Kent et al 2010; Gray et al, 2011). Gray et al also report that a smoker is seven times more likely to develop an AAA than a non-smoker. Less common risk factors that can contribute to AAA development include infection, arthritis, trauma, connective tissue disorder or cystic medial necrosis (Gray et al, 2011). Inflammatory mechanisms may also play a role in the risk of AAA growth (Wanhainen, 2004).

4.4 Surveillance

A study of the ten year outcome of patients with very small AAA by Biancari et al (2002) concludes that the fate of a small AAA is to slowly enlarge, to a point where it becomes life threatening, underlining the importance of AAA surveillance. Gibbons et al (2018) also highlight the significance of AAA surveillance by ultrasound, and how its use has decreased mortality by 20% to 60%.

The intervals between AAA surveillance visits depend on the maximum diameter of the AAA, with discordance existing between institutions according to the literature available on AAA follow up protocol. Ashton et al (2002) suggest that AAAs with a diameter of 3.0-4.4cm be rescanned yearly, and those that measure 4.5-5.4cm return every 3 months. However the UKSAT group (Cronenwett et al, 1999) advises that once

the AAA reaches 4.0cm the patient should be followed up every 6 months until the AAA becomes 5cm, then return every 3 months. Despite the variation in follow up protocol, most institutions agree that once an AAA reaches 5.5cm in maximum diameter, becomes symptomatic or there is a significant increase in diameter between visits (greater than 1cm per year), the patient should be referred to their consultant for consideration for surgical intervention.

Numerous studies confirm AAA surveillance using ultrasound as an effective diagnostic imaging modality that is safe, cost-effective, reproducible and non-invasive (Ashton et al 2002; Gibbons et al, 2018). For these reasons ultrasound is considered the gold standard imaging modality for AAA screening (Siso'-Almirall et al, 2017).

4.5 Intervention

Surgical intervention is appropriate in the treatment of AAA when cumulative risk of rupture outweighs the risk of AAA repair (Cao et al, 2005). The current approach where AAAs greater than or equal to 5.5cm should proceed to intervention is well defined, due to the risk of rupture being greater than 10% per year, and the perioperative mortality rate being 2.5-5% (Silaghi et al, 2007).

The UKSAT and ADAM studies both attempted to address the topic of management of aneurysm smaller than 5cm by performing randomised controlled trials of early intervention vs. surveillance; however both studies concluded that surveillance was safe and delayed intervention yielded similar 5 year survival rates. The UKSAT also concluded that in small AAA, intervention should be considered only in symptomatic patients or those with a greater than 1cm increase in diameter per year.

A further study by Schermerhorn et al (2000) suggested that although the UKSAT reported no survival benefits for early intervention, the trial lacked statistical power to detected small gains in life expectancy. This study concluded that earlier operations provided a small survival advantage, and may be cost effective for patients with small AAA, particularly in younger patients.

4.6 Screening Programmes

The World Health Organisation (WHO) defines screening as "the presumptive identification of unrecognised disease or defect by the application of tests, examinations, or other procedures which can be applied rapidly." (Wilson and Jungner, 1968). The following table outlines the criteria required to implement a screening programme:

1. The condition sought should be an important health problem.
2. There should be an accepted treatment for patients with recognised disease.
3. Facilities for diagnosis and treatment should be available.
4. There should be a recognisable latent or early symptomatic stage.
5. There should be a suitable test or examination.
6. The test should be acceptable to the population.
7. The natural history of the condition, including development from latent to declared disease, should be adequately understood.
8. There should be an agreed policy on whom to treat as patients.
9. The cost of case-finding (including diagnosis and treatment of patients diagnosed) should be economically balanced in relation to possible expenditure on medical care as a whole.
10. Case-finding should be a continuing process and not a "once and for all" project.

Table 4.1 WHO screening criteria[14]

Given that AAAs are predominantly asymptomatic, screening programmes for detection of AAA are necessary for effective treatment. Rupture is a strong rationale for screening for AAA, as preventative intervention has a much lower mortality and morbidity rate (Aboyans et al, 2010).

Chaikof et al (2009) recommend that one time ultrasound screening for AAA should be carried out in all males greater than 65 years old, or as early as 55 years if there is a family history of AAA. They also recommend AAA screening in females greater than 65 years who smoked or have a family history of AAA. Similarly, the U.S. Preventative Task Force recommend one time AAA screening for males ages 65-75 years of age who have ever smoked ≥100 cigarettes in their lifetime.

The current recommendations by the UK National Screening Committee are also to screen all males ≥65 years of age for AAA. This recommendation is based on the MASS trial which has proven that a single ultrasound significantly reduces the rate of premature death from AAA rupture (Davis et al, 2013). Numerous studies carried out in Chichester, Huntingdon and Gloucester in the UK and one in Denmark all yielded similar results (MASS). The MASS trial also suggested that there was a 32% reduction in AAA related deaths in a screened population of men. Screening females aged 60-85 years with cardiovascular risk factors, and both males and females greater than 50 years of age with a family history of AAA is recommended by Kent et al (2004).

Aboyans et al (2010) document that despite several international guidelines recommending AAA screening with ultrasound in a high-risk population, it is often poorly implemented. They looked at AAA screening during echocardiography and concluded that the feasibility to do so was greater than 90%; with an average of 2-7 minutes extra scan time.

The Norwegian Knowledge Centre for the Health Services produced a systematic review that concluded that evidence shows no reduction in overall mortality in males or females resulting from AAA screening. AAA screening is however beneficial in males greater than 65 years of age as it can reduced AAA related mortality by nearly half in the mid- to long-term, which concurs with the above recommendations (Frønsdal et al, 2014). This study states that the data indicates that there is no change in AAA related mortality for females greater than 65 years of age.

In a study by Chiu et al (2014) it is suggested that AAA diameter is underestimated using ultrasound when compared with CT, and that this underestimation in the UK NHS screening programme reduces the sensitivity of the screening, which may impact of the way findings are interpreted. However a study by Gray et al (2011) examined the accuracy of duplex ultrasound in measuring maximum AAA diameter prior to intervention compared to the gold standard method of CT, which demonstrated a large overall degree of correlation ($r = 0.95$).

Svensjö et al (2014) documented that four large randomised control trials provided evidence of a drop in AAA mortality by ultrasound based screening in elderly males. However, recent reports of falling AAA prevalence and mortality unrelated to AAA screening have emerged. The study states that these changes may affect the rationality of AAA screening and that re-screening in the elderly population may be needed with ever increasing longevity.

Ruff et al (2015) examined AAA screening in outpatient primary care clinics. They state that AAA screening rates currently remain below 50% but are improving over time. There is variation in the individual physicians who provide screening services, indicating the need for further education on the importance of AAA screening. Ruff et

al also point out that often, patients undergo unnecessary screening as AAA may have been previously picked up on another imaging modality and this should be checked before referral for screening, as it is a waste of resources.

In an audit conducted by Benson et al (2016) it is documented that the National Abdominal Aortic Aneurysm Screening Programme (NAAASP) is established across the UK and demonstrates significant benefit in terms of fewer emergency surgeries and a reduction in 30 day operative mortality. Benson states that a lower prevalence of AAA was picked up than was predicted, with only 1.2% of males screening having an AAA. This could be because NAAASP examines the general population; whereas this study expects to yield a much higher prevalence as it examines a high-risk cardiovascular population.

CHAPTER V

METHODOLOGY OF ANALYSIS OF ABDOMINAL AORTIC ANEURYSM SCREENING IN THE MATER MISERICORDIAE UNIVERSITY HOSPITAL

5.1 Study Design & Patient Selection

This is a retrospective audit of abdominal aorta duplex studies performed between 1st January 2010 and 31st December 2016.

5.1.1 Inclusion Criteria

All patients ≥ 60 years of age who had an abdominal aorta duplex performed within the stated timeframe for the purpose of AAA screening.

5.1.2 Exclusion Criteria

- All patients less than 60 years of age who had an abdominal aorta duplex performed within the stated timeframe.

- All patients who had an abdominal aorta duplex performed within the stated timeframe for the following purpose:
    - AAA surveillance
    - EVAR surveillance
    - Aorto-bi-fem graft surveillance
    - Referral for surveillance of an AAA picked up on another imaging modality
    - Referral for AAA screening due to a family history of AAA

5.2 Obtaining Data & Data Storage

5.2.1 Initial Data Collection

- Local ethical approval was sought and obtained to carry out this research study.
- An electronic list of all the vascular studies performed in MMUH vascular laboratory between 1st January 2010 and 31st December 2016 was obtained from the hospital electronic patient record (EPR) system in the form of a Microsoft Excel 2007 spreadsheet.
- This spreadsheet contained the following data:
    - Patient name
    - Patient medical record number (MRN)
    - Vascular laboratory attend date
    - Patient date of birth
    - Study description
    - Referring physician

- The spreadsheet was stored on a secure, networked MMUH vascular laboratory PC, in a shared drive with password protected access to vascular department staff only.
- The data was initially sorted by study description to determine the number and percentage of each of the following studies performed in the department in the given timeframe: ankle brachial index including toe pressures and exercise testing, carotid artery duplex, abdominal aorta duplex, lower limb arterial studies including bypass graft studies, lower limb venous studies including varicose veins, pre-operative vein mapping and deep venous duplex and other tests such as upper limb arterial and venous duplex, transcranial Doppler, temporal artery duplex, arteriovenous fistula and pseudoaneurysm duplex studies.

- The data for all the abdominal aorta duplex studies was extracted and compiled in a new spreadsheet; sorted by patient MRN, and by date.
- Each patient's age on the day they attended for their duplex study was determined in Excel using their date of birth and the vascular laboratory attend date.
- Some patients only had one abdominal aorta duplex study in the given timeframe. The reports from these studies were examined to identify the indication.
- All remaining patients had multiple abdominal aorta duplex studies in the given timeframe. The report from the earliest study was examined to determine the initial indication:
    - If the first study was for the purpose of AAA screening and was positive, this was documented and all further studies for the same patient were documented as surveillance studies.
    - If the first study was for the purpose of AAA screening and was negative, this was documented and the reports of the additional studies for the same patient were examined in date order to assess the indication for further abdominal aorta duplex studies.
    - If the first study's indication was for any reason stated in the exclusion criteria they were excluded.

- The studies to be included in and excluded from this research were determined from the documented indications for each abdominal aorta duplex.

5.2.2 Retrospectively Assessing Reports

The report for each abdominal aortic duplex for the purpose of AAA screening was obtained from "Patient Centre" (the electronic patient record of the MMUH). From these reports the following information was documented in the Excel spreadsheet:

- Patient gender
- Indication for study
- Maximum abdominal aorta size
- Maximum common iliac arteries size (right and left)
- If the study was inconclusive

5.3 Analysing Data

All data was analysed using Microsoft Excel 2007. Using a pivot table the following patient demographics were determined:

- Male to female ratio
- Minimum and maximum age
- Mean age and standard deviation

Using the 'IF' Microsoft Excel function on the documented aortic and common iliac artery diameters the data was organised into the following categories:

- Normal aorta (an abdominal aortic diameter $\leq$2.5cm)
- Ectatic aorta (an abdominal aortic diameter 2.6cm – 2.9cm)
- Positive for AAA (an abdominal aortic diameter $\geq$3cm)
- Isolated common iliac artery aneurysm

The positive AAAs were further analysed into the following categories using the 'IF' Microsoft Excel function:

- Small AAA (3.0cm-3.9cm)
- Medium AAA (4.0cm-4.9cm)
- Large AAA (5.0cm and over)

Further analysis using a pivot table was performed on each size group to determine the male to female ratio and the mean age and standard deviation of both gender groups. Statistical analysis was performed to show whether the results were statistically significant for each group. The aim of tests of significance is to calculate the probability that the outcome has happened by chance. This probability is known as the "p-value". If the p-value is small ($p<0.05$), the null hypothesis can be rejected and the findings are statistically significant (Gupta, 2012). A summary table was made using Excel to highlight the overall results.

CHAPTER VI

OUTCOMES OF DATA ANALYSIS

6.1 Introduction & Aims

This study was a retrospective clinical audit of the current MMUH vascular laboratory AAA screening programme. It included all patients 60 years of age and over who received an abdominal aorta duplex study for the purpose of AAA screening between 1st January 2010 and 31st December 2016. The main study aims were:

- To determine the prevalence of AAA within a high-risk cardiovascular population.
- To determine if the current criteria for AAA screening should be modified to suit the population referred to the MMUH vascular laboratory.

Between 1st January 2010 and 31st December 2016 a total of 55,574 vascular studies were performed in MMUH, which were composed of the following:

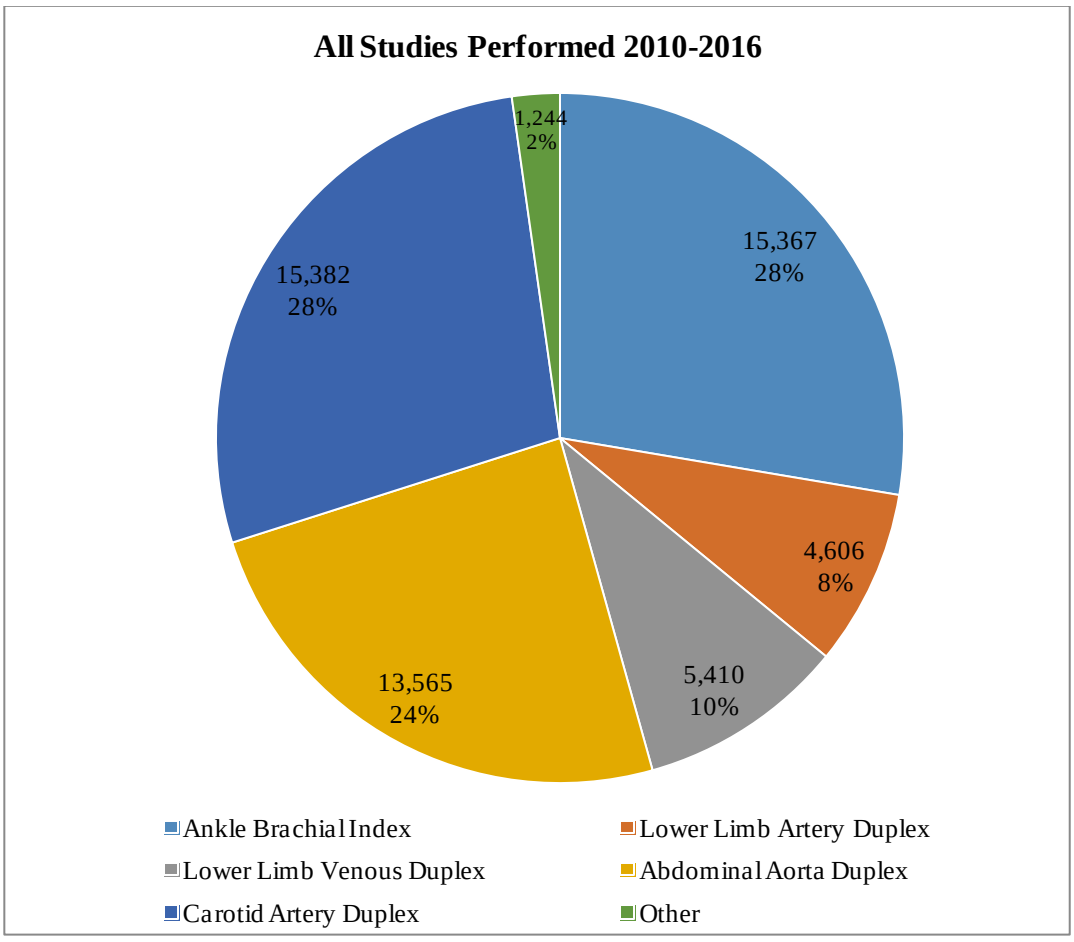

Figure 6.1 All Studies Performed 2010-2016

6.2 Abdominal Aortic Duplex Studies

Of the 55,574 overall studies performed in the vascular laboratory, 13,565 were abdominal aorta duplex studies that were performed on 7,149 patients; some of whom had multiple studies performed under the MMUH AAA surveillance programme. The report for each patient's first abdominal aorta duplex study within this timeframe was examined and the indication for the study was assessed. Of these studies, 6,656 were performed solely for the purpose of AAA screening. The remaining studies were performed on patients already under surveillance for AAA, EVAR or any other aortic intervention prior to 2010 and therefore excluded from analysis as outlined in chapter V. Of the studies performed solely for the purpose of AAA screening 567 studies were performed on patients less than 60 years old and therefore excluded for being outside of the scope of the screening programme criteria, leaving 6,089 AAA screening studies.

6.3 Abdominal Aortic Duplex for AAA Screening

6.3.1 Patients Referred for AAA Screening

Of the 6,089 studies performed for AAA screening, 667 were referred to the vascular laboratory for the purpose of screening due to an incidental finding of AAA on another imaging modality such as CT, general ultrasound, X-ray, magnetic resonance imaging (MRI) or angiography. Other referral reasons included family history of AAA, blue toe syndrome, a palpable abdominal aorta or aneurysmal dilation elsewhere in the arterial system. These 667 studies were excluded from the analysis as they were not deemed to be truly representative of coincidental AAAs found during screening.

6.3.2 True AAA Screening

Having made all exclusions necessary to fulfil the audit criteria, the true number of studies performed for the purpose of AAA screening was 5,422. Of these, 3,261 (60%) were male with a mean age of 72 ± 7.7 years; and 2,161 (40%) were female with a mean age of 74 ± 8.1 years ($p<0.001$).

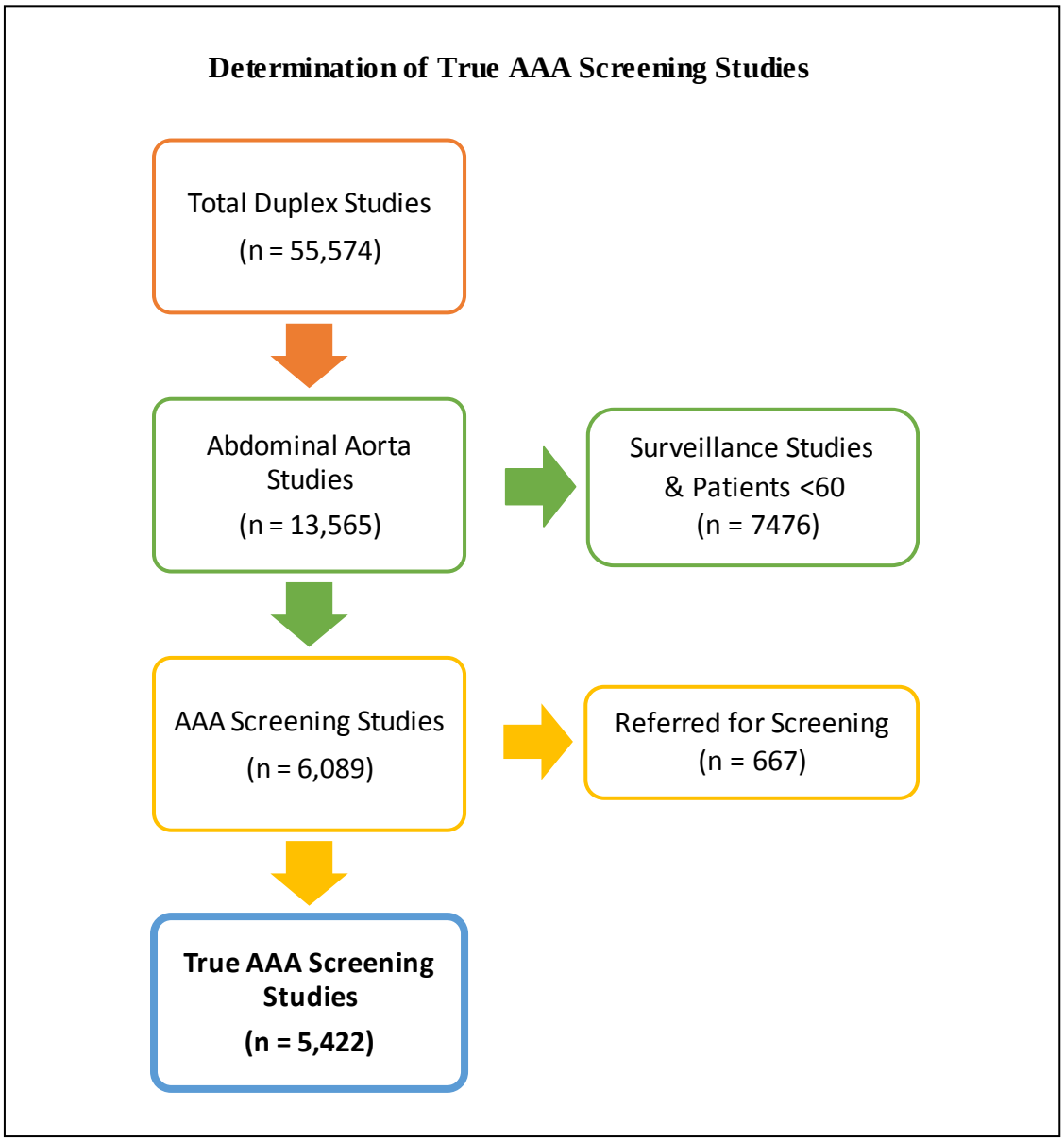

Figure 6.2 Determination of True AAA Screening Studies

6.4 Overall Prevalence

Of the 5,422 AAA screening studies:

- 4,320 (79.7%) showed no abdominal aortic or common iliac artery dilatation.
- 328 (6.1%) were positive for AAA (aortic diameter ≥3cm).
- 228 (4.2%) showed an ectatic abdominal aorta (aortic diameter 2.6cm-2.9cm).
- 72 (1.3%) showed isolated common iliac artery dilatation (diameter ≥1.5cm).
- 474 (8.7%) were inconclusive due to overlying bowel gas or patient body habitus.

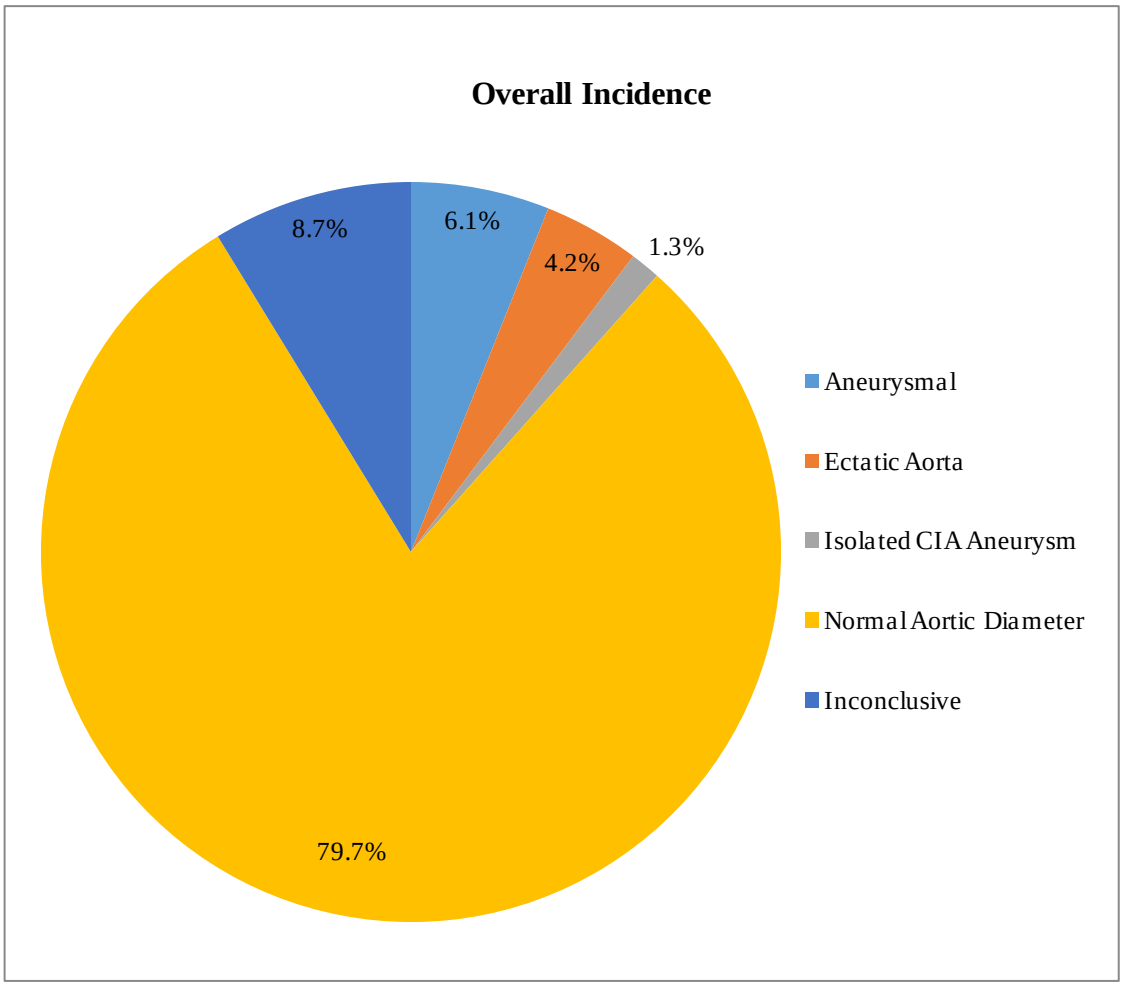

Figure 6.3 Overall Prevalence

6.5 Analysis of Ectatic Aorta & Positive Abdominal Aortic Aneurysms

6.5.1 Ectatic Aorta

Of the 228 AAA screening studies that showed an ectatic abdominal aorta, 180 (79%) were performed on males with a mean age of 75 ± 8.0 years; and 48 (21%) were performed on females with a mean age of 76 ± 6.8 years (p=0.22).

6.5.2 Positive Abdominal Aortic Aneurysms

Of the 328 AAA screening studies that were positive for AAA overall, 260 (79%) were performed on males with a mean age of 74 ± 7.4 years; and 68 (21%) were performed on females with a mean age of 78 ± 7.6 years. Males accounted for 4.8% of the total AAA prevalence and females for 1.3% (p<0.001). The average overall AAA size was 3.9cm ± 0.9cm.

The positive AAAs were further analysed in the following sub-groups:

- Small AAAs (aortic diameter 3.0cm-3.9cm)
- Medium AAAs (aortic diameter 4.0cm-4.9cm)
- Large AAAs (aortic diameter ≥5.0cm)

Of the 672 males aged between 60 and 64, 31 (4.6%) AAAs were detected. Of these, 18 were small, 13 were medium or large. Of the 301 females aged between 60 and 64, only 4 (1.3%) AAAs were detected, all of which were ≤3.3cm (p=0.08).

6.6 Analysis of Positive AAA Sub-Groups

6.6.1 Small Abdominal Aortic Aneurysms (3.0cm-3.9cm)

Of the 328 positive AAAs, 221 were small AAAs. Of these, 174 (79%) were found in males with a mean age of 74 ± 7.6; and 47 (21%) were found in females with a mean age of 78 ± 8.2 (p=0.009).

6.6.2 Medium Abdominal Aortic Aneurysms (4.0cm-4.9cm)

Of the 328 positive AAAs, 73 were medium AAAs. Of these, 57 (78%) were found in males with a mean age of 74 ± 7.1; and 16 (22%) were found in females with a mean age of 78 ± 6.3 (p=0.04).

6.6.3 Large Abdominal Aortic Aneurysms (≥5.0cm)

Of the 328 positive AAAs, 34 were large AAAs. Of these, 29 (85%) were found in males with a mean age of 74 ± 6.9; and 5 (15%) were found in females with a mean age of 80 ± 6.1 (p=0.07).

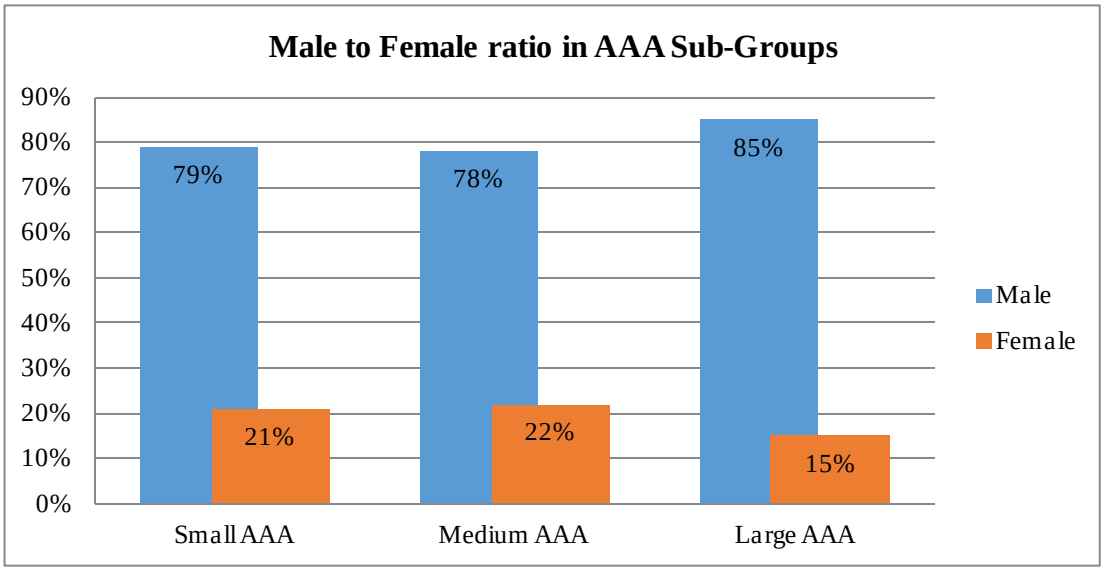

Figure 6.4 Male to female ratioin AAA sub-groups

6.7 Summary of Outcomes

Aorta Size	Male	Female	Male Mean Age (years ± SD)	Female Mean Age (years ± SD)	P-value
Total Screened (n=5,422)	60%	40%	72 ± 7.7	74 ± 8.1	<0.001
Normal (n=4,320)	57%	43%	72 ± 7.6	74 ± 8.1	<0.001
Ectatic (n=228)	79%	21%	75 ± 8.0	76 ± 6.8	0.22
Small AAA (n=221)	79%	21%	74 ± 7.6	78 ± 8.2	0.009
Medium AAA (n=73)	78%	22%	74 ± 7.1	78 ± 6.3	0.04
Large AAA (n=34)	85%	15%	74 ± 6.9	80 ± 6.1	0.07

Table 6.1 Summary of Outcomes

CHAPTER VII

DISCUSSION OF STUDY OUTCOMES

Based on the finding of the MASS trial in the UK and by the US Preventive Services Task Force in the United States, AAA screening has been recommended for over 15 years. Ultrasound screening for AAA in high-risk populations can significantly reduce aneurysm related mortality, is cost effective and follows the WHO criteria for screening. The main focus of this study was to perform a clinical audit of the current AAA screening programme in place in the vascular laboratory in the MMUH, to determine the prevalence of AAA in a high-risk cardiovascular group within the Irish population and to determine whether the current AAA screening criteria needs modification to better utilise resources.

This study resulted in an overall AAA prevalence of 6.1%. This figure is higher than that of similar studies such as the ADAM study (Lederle et al, 2000), the MASS trial (Ashton et al, 2002), a screening programme performed in Northern Ireland (Badger et al, 2011) and the NAAASP in the UK (Jacomelli et al, 2016); which resulted in a prevalence of 3.6%, 4.9%, 5.4% and 1.3% respectively. However, these studies were based on the general population in comparison to this study which was based on a high-risk cardiovascular population, showing that the high-risk population attending vascular laboratories are ideal candidates for AAA screening. It is undeniable that AAA screening has proven its importance by the detection of undiagnosed disease.

Currently the UK National Screening Committee recommends one time AAA screening by ultrasound for all males 65 years of age and over based on the results of the MASS trial (Davis et al, 2013). This study included all patients 60 years of age and over, including females; and resulted in a higher AAA prevalence than that observed in the other literature.

The increased detection rate found in this study is hardly surprising considering the cohort of patients screened already have many of the risk factors associated with AAA and are considered to be at a higher risk than the general population, in which the probability of developing an AAA is low. Risk factors such as increasing age, smoking, male gender, hypertension and hypercholesterolemia are associated with development of both peripheral vascular disease and AAAs (Chaikof et al, 2009; Gray et al 2011).

The prevalence of ectatic aortas identified in this research was 4.2%. This diameter range was included in this study as there is evidence to suggest that 14% of abdominal aortas with an initial diameter of 2.6-2.9cm will exceed 5.5cm within 10 years (Chaikof et al, 2009). The age range of the population with ectatic aortas in this study was 60-92 years, with a mean age of 75 years in males and 76 years in females. Twenty five percent of those with ectatic aortas were in their 60's; so it is likely that these patients may indeed go on for AAA repair within a decade of the discovery of their ectatic aorta, as the mean age of those with large AAAs in males and females were 74 and 80 years respectively.

A large meta-analysis study performed by Li et al (2013) examined the combined findings from 56 AAA screening studies and showed that the prevalence of AAAs with diameters between 3.0cm-3.9cm is higher than those with a diameter of >4.0cm. These results are in keeping with this study's findings as there was a decrease in prevalence as the documented AAA size increased; with 221 small AAAs (3.0cm-3.9cm), 73 medium AAAs (4.0cm-4.9cm) and 34 large AAAs (≥5.0cm).

The male to female ratio was approximately 4:1 in the entire group; and each sub-group analysis showed similar findings. This is lower than some of the literature, which suggests a ratio of 6:1 (Scott et al, 2002). The study by Scott et al was a randomised trial including 9,342 women in the general population whereas this audit included 2,169 women in a high-risk cardiovascular population. However a study by Singh et al (2001) examining a group of 6,386 patients, documented similar findings to this audit with an approximately four times higher prevalence of AAA in males.

The mean age of males in each of the AAA sub-groups was 74 years. The mean age of females was 78 years in the small and medium AAA sub-groups and 80 years in the large AAA sub-group. A study by Barba et al (2005) resulted in similar mean ages; with 69 years in men and 81 years in women. The same study also states that AAAs occur approximately 10 years later in females than in males, which does not correspond to the results of this research. There is a statistically significant difference in the male to female mean ages in the overall AAA group, the small AAA group and the medium AAA group. The large AAA group is not statistically significant however it is very close ($p = 0.07$). The small number of females in this group may have resulted in a lack of statistical power, and had there been a larger number of females it is more likely to have been statistically significant.

Of the total 5,422 patients in this study, 72 (1.3%) were found to have isolated common iliac artery dilatation (diameter $\geq$1.5cm). This finding is in keeping with the literature, suggesting that isolated iliac artery aneurysms are rare, occurring in less than 2% (Dix et al, 2005).

It is commonly debated amongst the literature whether the 'normal' aortic diameter in women should be taken into consideration when defining an AAA, as typically women's vessels are smaller than men's. Similarly the physical size of the patient can be brought into question. However as there is the possibility for each individual to have slight variation in their make-up and in what can be considered normal, we need set reference points when it comes to surveillance and treatment of diseases such as AAAs. The sum of evidence currently available provides no good reason to alter the definition of an AAA based on gender (Lederle et al, 2000). However the more recent recommendations from the ESVS (2019) suggest that elective AAA repair may be considered at 5.0cm in women. Any variation in following these guidelines based on an individual is at the discretion of the physician looking after the patients' care.

The mean AAA size in this study was 3.9cm ± 0.9cm. It is documented by Li et al (2013) that the average growth rate of aneurysms is between 0.28 and 0.38 cm/year. Based on this, we can predict that within 10 years the mean AAA size will have increased above the 5.5cm cut off point for recommended repair, given that the overall mean age of those positive for AAA was 74 years in men and 78 years in females.

Several potential limitations were discovered during this research with regards lack of available data on the prevalence of AAA in the female population; and a lack of studies performed on the Irish population. Currently there are no statistics available regarding the prevalence of AAA in Irish females; therefore this series is potentially the first.

A large cohort of women were screened for abdominal aortic aneurysms in this study, which offers insight into the prevalence rates in an under-represented gender group with

cardiovascular disease. In the limited available literature on the prevalence of AAA in women, prevalence rates have been found to be between 0.4% and 2.2% (Lederle et al 2001; Singh et al 2001), which is in keeping with the 1.3% found in this study. Singh's study included 3,424 women, which is not too dissimilar to the number of females included in this study.

Derubertis et al (2007) also highlighted the lack of data available regarding AAA screening in females. Their study included 10,012 women with a mean age 69.6 years, compared to the 2,169 with a mean age of 74 ± 8.1 years in this study. Derubertis documents an overall prevalence of 0.7% in women, lower than that found in this study, however on further analysis showed that women with multiple atherosclerotic risk factors resulted in a prevalence as high as 6.4%.

Brosnan (2011) performed a screening on 904 Irish males aged 55-75 years that showed an AAA prevalence of 1.9%. The patients included in the study represented a cross-section of the general population, unlike this study, which targeted a high-risk cardiovascular population and as a result found a significantly higher prevalence of AAA. However, the accuracy of the prevalence in the study by Brosnan is brought into question as only the anterior-posterior wall diameter was documented when measuring the AAA. The accepted method of obtaining maximum AAA size is to measure both the anterior-posterior wall diameter and the transverse wall to wall diameter and document the larger of the two values (Ashton et al, 2002). This was the method used in the MASS trial, and is currently the method used by the MMUH vascular laboratory and the NAAASP in the UK.

The current UK guidelines restrict AAA screening to males aged 65 and over. The same limitations are not applied to the population screened for AAA in the MMUH vascular laboratory as both males and females aged 60 years and over are included. Had the UK recommended guidelines been applied to the data obtained in this study, a total of 172 studies (3.2%) that showed either ectatic or aneurysmal abdominal aortas would not have been detected. As women are not screened for AAA under the UK guidelines, the 116 ectatic or aneurysmal aortas detected in women in this study would have been missed. Of these, 95 were classified as ectatic aortas or small AAAs; with 21 having an AAA greater than 4cm. Of these, 5 had an aortic diameter greater than 5.0m and in need of AAA repair. The remaining 56 patients were men aged 60-64. Of these, 43 were classified as ectatic aortas or small AAAs; with 13 having an AAA greater than 4cm. Only 1 of these had an aortic diameter greater than 5.5cm.

When the population group aged 60-64 was considered, only 4 out of 301 females had an AAA, all of which were small (≤3.3cm). When statistical analysis was performed on the AAA size in this age group comparing males and females, the result was borderline statistically significant ($p=0.08$). These results suggest that it is not necessary to perform AAA screening on females age 60-64 given the small percentage and the small size of those detected. No intervention would occur for this small percentage for many years until the AAA was significantly larger in any case, and given that they would likely be picked up if scanned at ≥65 years of age, excluding females aged 60-64 would save vascular laboratory resources at no risk to the population being examined. Had there been more females in this age group we could have more statistical power to prove this conclusively.

CHAPTER VIII

CONCLUSION & RECOMMENDATIONS FOR FUTURE RESEARCH & CLINICAL PRACTICE

8.1 Conclusion

- The prevalence of AAA in this study was found to be 6.1%, which is higher than that reported in the studies used for the current recommendations for AAA screening in the UK. This shows that AAA screening in the MMUH vascular laboratory is justified for the high-risk cardiovascular population being assessed.

- Based on the results of this study the following conclusions were reached in relation to the MMUH AAA screening criteria:
  - No change to be made to the male age profile being assessed (≥60 years).
  - Increase the female age profile being assessed to ≥65 years.

8.2 Further Research & Recommendations

- This study examined the prevalence of AAAs in a high-risk cohort of patients but did not record the risk factors for each patient who attended the vascular laboratory, or the degree of vascular disease present. It may be beneficial in future to record these parameters in order to determine the relationship between these conditions, allowing for further alteration of the MMUH AAA screening criteria to focus of a certain group within this cohort of cardiovascular patients.

- There is a notable paucity of data regarding AAAs in females. Further research into AAAs in females may be warranted, particularly in those who are high-risk.

- This study recommends that similar AAA screening programmes be established in all Irish vascular laboratories to provide a nationwide AAA screening programme.

As has been demonstrated in the UK, such a programme would have a positive impact on reducing the mortality rate from AAA in this country.

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