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Research Article

What is the Relationship Between Chronic Heart Failure and Operation size? A systematic Review

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Abstract:

Background:

Heart failure is a chronic progressive failure of the heart muscle to pump blood to meet the body's oxygen demands. Heart failure impacts on perioperative outcomes of non-cardiac surgery, with higher risks of post-operative complications and mortality. The aim of this study was to review current clinical evidence to assess if there was a relationship between heart failure, operation size and post operative outcomes

Methods:

PRISMA guidelines were implemented to complete a systematic review. The review was pre-registered with the International Prospective Register of Systematic Reviews (PROSPERO) (ID: CRD42022313897). PubMed was searched from 1940 to 2022 using the terms "heart failure", "noncardiac surgery", "thyroid surgery", "breast surgery", "asymptomatic carotid endarterectomy", "hernia", "cholecystectomy". "laparoscopy", laparotomy", "peripheral angioplasty", "EVAR", "neck of femur", "abdominal aortic aneurysm", and "lower extremity revascularisation". Inclusion criteria included: experimental and observational studies; pre operative diagnosis of heart failure; 30d morbidity and mortality; non cardiac surgery.

Results:

47 articles relevant to the inclusion criteria were analysed. Five studies assessed low risk operations; 29 assessed intermediate risk operations; 8 assessed high risk operations; 5 assessed intermediate and high-risk operations. For low, intermediate and high-risk operations, heart failure was associated with a statistically significant increased risk of mortality and morbidity ($p<0.05$).

Conclusions:

Heart failure is associated with increased morbidity and mortality independent of operation size or risk. Challenges remain in assessing the relationship between heart failure and operation outcome due to variations in disease spectrum and the impact of additional co-morbidities.

keywords: heart failure; morbidity; mortality; perioperative risk; surgery

Introduction

Heart failure is a physiological failure of the heart pump to meet the body's demands for oxygen. It is diagnosed as a constellation of signs and symptoms, and a demonstrated reduced left ventricular ejection function (LVEF) or preserved LVEF with structural disease and/or diastolic dysfunction, on echocardiogram [1]. Symptoms include breathlessness, fatigue and reduced exercise tolerance. Clinical signs of right sided heart failure include peripheral oedema, whilst left sided heart failure is characterised by signs of pulmonary oedema including tachypnoea, raised jugular venous pressure and reduced oxygen saturations. Heart failure is common, and in developed countries, affects >10% of the population >70 years old [2]. It is a progressive condition although has an unpredictable course [3]. Heart failure can be categorised using either ACC/AHA classification (Table 1) [4] or New York Heart Association (NYHA) functional classification (Table 2) [5].

STAGE	DESCRIPTION	EXAMPLES
STAGE A	Asymptomatic patients at risk of developing heart failure due to their co-morbidities. These patients have no structural or functional cardiac abnormalities, and show no signs of heart failure	Hypertension, coronary artery disease, diabetes mellitus, history of rheumatic fever
STAGE B	Those who are asymptomatic but have structural heart abnormalities associated with heart failure	Left ventricular hypertrophy, left ventricular fibrosis, valvular heart disease, previous infarction
STAGE C	Those with current or previous symptoms of heart failure in association with structural heart changes	Dysnpnoea with left ventricular systolic dysfunction; patients being treated for heart failure who are currently symptom free
STAGE D	Those who suffer symptoms of heart failure at rest, despite maximal medical therapy (refractory heart failure)	Patients admitted to hospital for management of heart failure, patients who cannot be discharged from hospital due to heart failure, patients awaiting heart transplant

Table 1: American College of Cardiology/ American Heart Association time line classification of heart failure

STAGE	SYMPTOMS
NYHA I	No limit on physical activity
NYHA II	Symptoms of fatigue, palpitations or dyspnoea on ordinary exertion
NYHA III	Symptoms of fatigue, palpitations or dyspnoea on less than ordinary exertion. Comfortable at rest.
NYHA III	Symptoms at rest, increased with any activity

Table 2: New York Heart Association (NYHA) classification of heart failure

Heart failure impacts on perioperative outcomes of non-cardiac surgery. Patients with heart failure have been shown to have a higher risk of 90-day post-operative mortality and 30-day post-operative complications, than patients without heart failure [6,7,8,9,10,11]. This risk is proportional, and mortality risk increases as systolic function decreases [6,12,13] or in cases of acute heart failure [9]. Increased mortality is also observed in both elective and emergency non-cardiac procedures [7,14]. The rates of post-operative mortality may be higher in woman than men with heart failure [11]. Overall, the mechanism of increased mortality is poorly understood.

Alongside increased mortality, patients with heart failure undergoing non-cardiac surgery suffer increased post-operative morbidity. Post-operative cardiac events are more frequent in patients with heart failure [15,16,17,18,19,20]. This is the case for patients with reduced right heart function, as well as patients with lower LVEF [21,22]. Cardiac complications are associated with longer inpatient stays, death and higher costs [16,17]. As well as cardiac complications, patients with heart failure are at increased risk of post-operative pulmonary embolism, acute renal failure, need for mechanical ventilation for over 48 hours, unplanned intubation, cerebrovascular event, pneumonia, urinary tract infection, sepsis and admission to intensive care [20,23,24]. These patients are more likely to require hospital readmission [7]. This highlights the importance of identification of patients with heart failure, and their optimisation during the perioperative period.

Materials and methods:

A systematic review of articles was performed to assess outcomes of patients with heart failure for different operations, based on the Preferred Report Items for Systematic Reviews and Meta-Analysis (PRISMA) statement. The review was registered with PROSPERO (ID CRD42022313897).

Inclusion and Exclusion Criteria:

In this review, the relationship between heart failure and size of operation was assessed by classifying operations as low, intermediate or high risk (Table 3). The relationship was assessed in the perioperative and immediate post-operative period (30-day post procedure). Patient morbidity and mortality were assessed as opposed to the long-term operative success. Outcomes were assessed in individuals with heart failure, compared to those without heart failure.

Inclusion criteria:

- Experimental and observational studies
- Outcomes for patients diagnosed with heart failure preoperatively
- Outcomes in the perioperative and immediate post-operative period (30 days)
- Non-cardiac surgeries

Exclusion criteria:

- Case reports
- Heart failure assessed as a component of a score, or combined with other co-morbidities
- Assessment of coronary artery disease or ischaemic heart disease without reference to heart failure
- Cardiac surgery and type A dissection

Search methods and selection of studies:

Pubmed was searched from 1940 to 2022 based on the following search terms: “heart failure”, “ noncardiac surgery”, “thyroid surgery”, “breast surgery”, “asymptomatic carotid endarterectomy”, “hernia”,

"cholecystectomy". "laparoscopy", laparotomy", "peripheral angioplasty", "EVAR", "neck of femur", "abdominal aortic aneurysm", and "lower extremity revascularisation". These terms were selected following the definition of these surgeries as low, intermediate and high risk (Table 3). Each of these terms was searched independently alongside "heart failure". No filters or limits were applied. Analysis of paper screening and selection was demonstrated (Figure 1).

LOW RISK	INTERMEDIATE RISK	HIGH RISK
Minor gynaecological/ orthopaedic/urological	Major gynaecological/orthopaedic/ urological	Major vascular/aortic surgery
Breast	Intraperitoneal (cholecystectomy)	Repair of perforated viscus
Thyroid	EVAR	Oesophagectomy
Dental	Peripheral angioplasty	Pneumonectomy
Eye	Symptomatic carotid endarterectomy/stenting	Liver transplant
Asymptomatic carotid endarterectomy/stenting		

Table 3: Estimation of surgical risk according to procedure [adapted from 30]

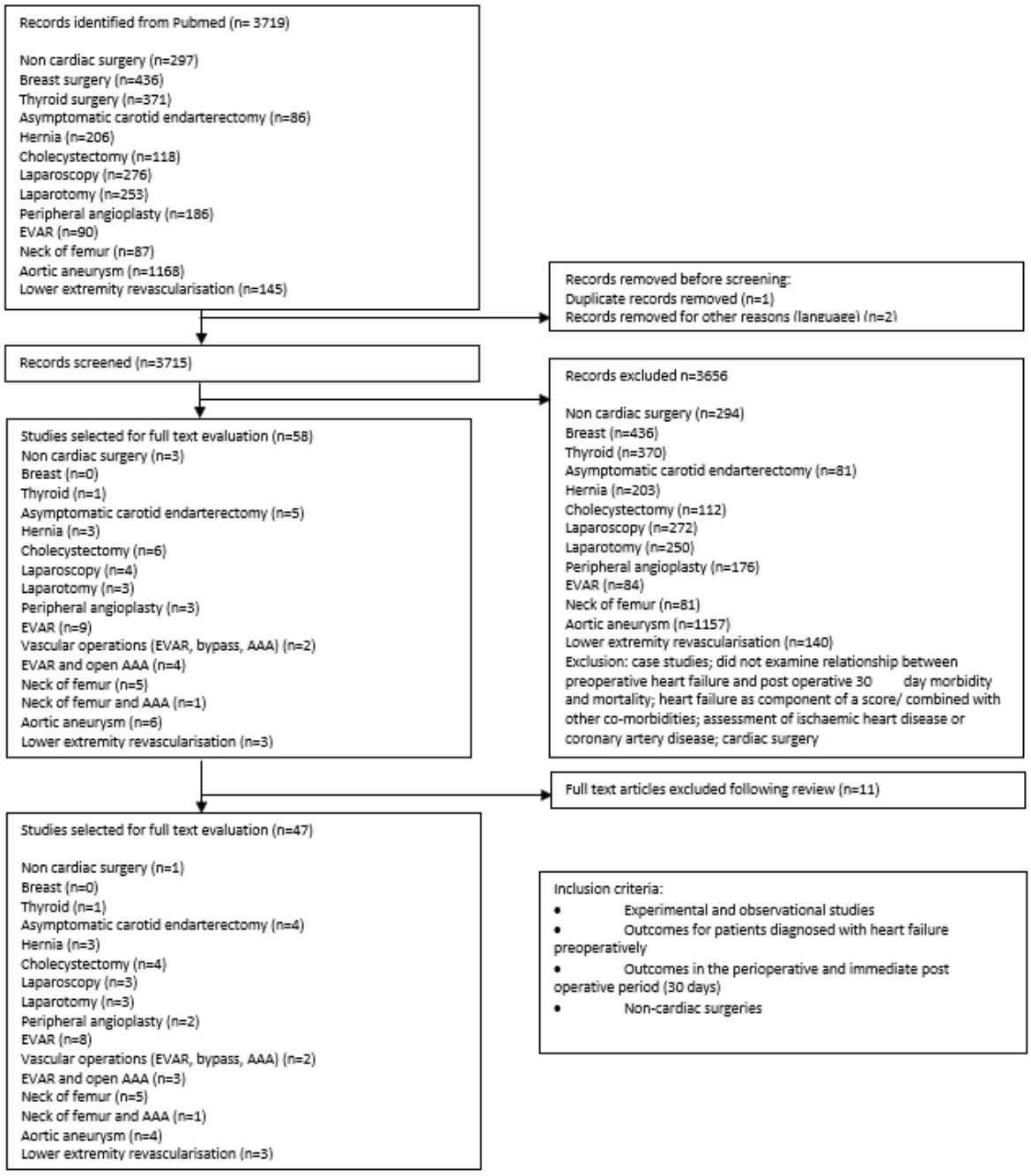

Figure 1: PRISMA flow chart for selection of papers for review

Each search was performed independently by the two lead authors to avoid bias, and articles which did not meet the inclusion criteria were rejected. Paper title and abstracts were assessed for relevance independently by the two authors, and full texts were examined in cases where relevance was not clear from this initial screen. Selected articles were read and rejected if they did not meet the inclusion criteria. This data was extracted from included papers and transferred to an Excel spreadsheet, and collated into tables (Tables 4,5,6).

Study	Type of study	Study period	Operation	Number of participants	Morbidity	Morbidity statistics	Increased 30d mortality
[28]	Prospective multicentre national database	2005-2007	Thyroid	10,838	Return to operating room	OR 6.83 95% CI 1.81-25.80	-
[29]	Prospective multicentre national database	2005-2012	Asymptomatic CEA	24,211	Stroke	P<0.001	P<0.001
[30]	Prospective multicentre	1988-1990	Asymptomatic CEA	1160	Perioperative stroke	P= 0.03	P=0.03
[31]	Prospective multicentre	1998-1999	Asymptomatic CEA	6553	Stroke	OR 0.63 95% CI 1.09-2.43 P=0.0294	OR 0.63 95% CI 1.09-2.43 P=0.0294
[32]	Prospective multicentre national database	1998-2021	Asymptomatic CEA	1,583,614	Myocardial infarction	P <0.001	-

Table 4: Table demonstrating relationship between heart failure and post-operative morbidity and mortality in low risk surgeries

Study	Type of study	Study period	Operation	Number of participants	Morbidity	Morbidity statistics	Increased 30d mortality
[34]	Prospective multicentre national database	2009-2010	Ventral and incisional hernia: emergency; elective	28,286	Prolonged length of stay for incarcerated/strangulated hernias following ventral/ inguinal hernia repair	P<0.040	-
[35]	Prospective multicentre	2008-2014	Elective ventral hernia: open; laparoscopic	103,635	-	-	OR= 2.15 95% CI 1.32-3.47 P=0.002
[36]	Prospective multicentre national database	2007-2008	Inguinal hernia: open, laparoscopic, emergency and elective	2,377	Wound complications, pulmonary complications, urinary tract complications, cardiac complications	OR 4.3 95% CI 1.5-12.6	-
[37]	Prospective multicentre national database	2007-2015	Cholecystectomy: open and laparoscopic	478,111	Hospital length of stay	P<0.001	OR 1.31 95% CI 1.16-1.48 P<0.001

[38]	Prospective multicentre national database	2008-2012	Elective and emergency laparoscopic cholecystectomy	143,761	Pneumonia or reintubation	P<0.01	P<0.01
[39]	Prospective multicentre national database	1998-2016	Cholecystectomy: open and laparoscopic	282,184	Pneumonia	OR 1.965 95% CI 1.587-2.438 P<0.0001	-
[40]	Prospective multicentre national database	2009-2010	Cholecystectomy: open and laparoscopic	53,632	30d readmission	OR 2.1 95% CI 1.8-2.4 P<0.0001	-
[41]	Prospective single centre	1993-2006	Elective laparoscopic sigmoid resection for diverticular disease	526	Post operative medical complications (pneumonia, pulmonary embolism, thrombosis, cardiac failure or infarction, renal failure)	OR 3.27 95% CI (1.37-7.8) P<0.008	-
[42]	Prospective multicentre database	2005-2012	Bariatric surgery: laparoscopic; open;	102,869	Post operative pulmonary embolism (PE) (laparoscopy)	OR 6.03 95% CI 1.45-25.10 P<0.014	-
					Post operative deep vein thrombosis (DVT) (laparoscopy)	OR 4.64 CI 95% 1.13-19.11 P<0.034	
					Post operative PE (open)	OR 10.32 CI 95% 1.29-82.65 P<0.028	
					Post operative DVT (open)	OR 7.72 CI 95% (0.97-61.49) P<0.053	
[43]	Prospective multicentre database	2004-2007	Elective left-colon resection, colostomy, ileostomy for diverticulitis	22,752	Haemorrhage	OR 1.5 95% CI 1.69-2.27	OR 3.5 95% CI 2.59-4.63
					Wound	OR 1.9 95% CI 1.50-2.39	
					Pulmonary	OR 4.2 95% CI 3.59-4.85	
					Cardiac	OR 4.6 95% CI 3.68-5.74	
					Sepsis	OR 3.2	

						95% CI 2.53-4.35	
					Renal	OR 4.1 95% CI 3.22-5.12	
					Thromboembolic	OR 1.6 95% CI 1.00-2.50	
[44]	Prospective multicentre	1993-1999	Elective colectomy via laparotomy	1721	Colorectal cancer morbidity	OR 3.0 CI 95% 1.42-6.32 P=0.003	-
[45]	Prospective multicentre	2005-2007	All abdominal surgeries	202	Surigcal site infection	OR 1.9 95% CI 1.20-3.04 P=0.011	-
[46]	Prospective multicentre	1997-2009	Damage control laparotomy with open abdomen for acute general and vascular	67	-	-	OR 11.4 95% CI 1.01-128.03
[47]	Prospective multicentre database	2015-2016	EVAR, CEA, open AAA, peripheral bypass	88,791	Post operative MI	P<0.001	-
[48]	Prospective multicentre database	2012-2017	EVAR, CEA, open AAA, peripheral bypass	26,231	Post operative MI	OR 1.52 95% CI 1.16-1.98	
[50]	Prospective multicentre	2012-2014	Infrainguinal endovascuular intervention	4449	30 day redmission	OR 1.6 CI 95% 1.1-2.5	-
[51]	Prospective multicentre database	1997-2010	Percutaneous angioplasty for peripheral arterial disease	7568	-	-	OR 1.62 95% CI 1.32-1.98
[52]	Prospective single centre	2008-2017	EVAR	136	Myocardial injury (post operative rise in troponin)	P=0.016	-
[53]	Prospective multicentre database	2003-2016	Elective EVAR		Major adverse event (MI, dysrhythmia, heart failure, leg ischaemia, renal insufficiency, bowel complication, reoperation, surgical site	OR 1.7 95% CI 1.5-1.9 P=0.001	-

					infection, stroke, respiratory complication, no discharge home		
[54]	Prospectiv emulticentr e database	2003-2017	EVAR	28,240	In hospital event (MI, dysrhythm ia, heart failure, stroke, pneumonia , respiratory failure, renal failure, lower extremity ischaemia, bowel ischaemia, reoperatio n	OR 2.20 CI 95% 1.64-2.95 P< 0.001	-
[55]	Prospectiv emulticentr e database	2003-2014	Elective EVAR	3,979	Prolonged intubation	P<0.05	-
[56]	Prospectiv e two centre	1995-1998	EVAR	113	Adverse cardiac event	P = 0.005	-
[57]	Prospectiv e multicentre database	2005-2013	EVAR	21,769	Protracted length of stay	OR 1.8 CI 95% 1.4-2.4	-
[58]	Prospectiv e multicentre database	2012-2013	EVAR	3886	30 day readmissio n	P<0.5	-
[59]	Prospectiv e multicentre database	2012-2014	EVAR	120,646	30d readmissio n	OR 1.8 95% CI 1.4-2.3 P<0.0001	-
[60]	Prospectiv e multicentre database	2001-2004	EVAR	11,415	-	-	OR 2.4 95% CI 1.8-3.4 P<0.0001
[61]	Prospectiv emulticentr edatabase	2005-2010	Elective EVAR	11,229	-	-	P<0.05
[63]	Prospectiv e multicentre database	2014-2018	Elective TEVAR	1469	Non home discharge	P<0.05	-
[64]	Prospectiv e, multicentre database	2006-2007 and 2009-2010	Total hip replacemen t, total knee replacemen t, AAA repair	429,509	Readmissi on	OR 1.23 95% CI 1.28-1.38 P<0.001	OR 6.79 95% CI 5.48-8.42 P<0.001
					Length of stay	OR 2.5 95% CI 2.31-2.71 P<0.001	
[65]	Prospectiv esingle centre	2004-2018	Repair hip fracture	1992	-	-	OR 4.01 95% CI 1.10-8.78 P=0.009

[66]	Prospectiv esingle centre	2011-2014	Repair hip fracture	331	-	-	OR 6.2 CI 95% 1.8-20.9 P=0.003
[67]	Prospectiv esingle centre	2009-2013	Repair hip fracture	99	-	-	P=0.036
[68]	Prospectiv emulticentr e database	2005-2016	Total knee and hip replacemen t	537	Pneumonia	P=0.003	P<0.001
					Renal insufficien cy	P=0.040	
					Myocardia l infarction	P=0.050	
					Extended length of stay (>5)	P<0.001	
					Readmissi on	OR 1.23 95% CI (1.09-1.39)	
[69]	Prospectiv e single centre	2013-2017	Repair neck of femur fracture	285	Post operative aki	P<0.05	-

Table 5: Table demonstrating relationship between heart failure and post-operative morbidity and mortality in intermediate risk surgeries

Study	Type of study	Study period	Operation	Number of participants	Morbidity	Morbidity statistics	Mortality statistics
[27]	Prospective, multicentre database	1997-1998	Major non cardiac (abdominal, vascular, orthopaedic)	23,340	Readmission	P<0.001	P<0.001
[47]	Prospective, multicentre database	2015-2016	Infrainguinal bypass, open AAA	88,791	Post op MI	P<0.08	-
[56]	Prospective two centre	1995-1998	Elective open AAA repair	113	Adverse cardiac event	P=0.001	-
[60]	Prospective multicentre database	2001-2004	Open AAA repair	11,415	-	-	OR 2.1 95% CI 1.7-2.6 P<0.001
[64]	Prospective multicentre database	2006-2007 and 2009-2010	AAA	14,524	Increased length of stay	OR 1.78 95% CI 1.46-2.16 P<0.001	OR 3.54 95% CI 2.65-4.73 P<0.001
					Readmission	OR 1.47 95% CI 1.11-1.94 P<0.006	
[70]	Prospective single centre	1987-1988	AAA repair	72	Post operative cardiac failure	P=0.004	P<0.001
[71]	Prospective single centre	1991-2001	Open TAA	854	-	-	Or 1.85 95% CI 1.09-3.15 P=0.03
[72]	Prospective multicentre database	2002-2014	EVAR-c and primary open	6429	Major adverse cardiac event	OR 1.5 CI 95% 0.98-2.34	-
[73]	Prospective multicentre database	2009-2015	Open AAA repair and EVAR	33,332	30d readmission	P<0.05	-
[74]	Prospective multicentre database	2005-2010	Infrainguinal bypass	18,645	Cardiac event	P=0.007	P<0.0001
					Pneumonia	P=0.014	
					Prolonged intubation	P=0.011	
					Reintubation	P=0.014	
					Sepsis	P=0.011	
					Re-operation	P=0.022	
					LOS >9 days	P=0.0001	
[75]	Prospective multicentre database	2013-2016	Arterial reconstruction for revascularisation	2906	Major adverse limb event 30d after revascularisation	OR 1.10	
[76]	Prospective multicentre database	2011-2013	Infrainguinal bypass	1,055	-	-	OR 4.46 95% CI 1.20-16.57 P<0.025

Table 6: Table demonstrating relationship between heart failure and post-operative morbidity and mortality in high risk surgeries

Data extraction included: study type; study period; operation performed; number of patients; morbidity; and mortality. Association of heart failure and post-operative morbidity and mortality was demonstrated by comparing patients with preoperative heart failure, and those without. Results were assessed for significance based on odds ratio, confidence interval and p value.

Results:

PubMed identified 297 articles for "heart failure" and "noncardiac surgery", 436 articles for "heart failure" and "breast surgery", 371 articles

for "heart failure" and "thyroid surgery", 86 articles for "heart failure" and "asymptomatic carotid endarterectomy", 206 articles for "heart failure" and "hernia", 118 articles for "heart failure" and "cholecystectomy", 276 articles for "heart failure" and "laparoscopy", 253 articles for "heart failure" and "laparotomy", 186 articles for "heart failure" and "peripheral angioplasty", 90 articles for "heart failure" and EVAR", 87 articles for "heart failure" and "neck of femur", 1168 articles for "heart failure" and "aortic aneurysm", and 145 articles for "heart failure" and "lower extremity revascularisation". Articles were screened and duplicates removed. This led to the final inclusion of 47 articles. One study was included for thyroid surgery, 4 studies were included for asymptomatic carotid endarterectomy, 3 studies were included for hernia surgery, 4 studies were included for cholecystectomy, 3 studies were included for laparoscopy, 3 studies were included for laparotomy, 2 studies were included for peripheral angioplasty, 9 studies were included for EVAR, 5 studies were included for neck of femur fracture repairs, 4 studies were included for aortic aneurysm (AAA) repair, 3 studies were included for lower extremity revascularisation, and 1 study was included for noncardiac surgery. There were no studies which examined the relationship of outcomes of patients with heart failure undergoing breast surgery. One study assessed the relationship between heart failure and outcomes in both abdominal aortic aneurysm and hip/knee replacement. Two studies assessed the relationship between heart failure and outcomes in both open and endovascular abdominal aneurysm repair. Two papers looked at the relationship between heart failure and outcomes in all vascular operations (EVAR, peripheral bypass, open AAA repair).

Results are demonstrated in Table 4 for low-risk surgeries, Table 5 for intermediate risk surgeries, and Table 6 for high-risk surgeries.

Discussion:

Patients undergoing low, intermediate and high risk non-cardiac surgeries are at risk of increased morbidity and mortality [6, 26,27].

Heart failure and low risk surgeries:

There are limited studies on the outcomes of patients with heart failure undergoing low risk surgery. A large prospective, multi-centre national study of patients undergoing thyroid surgery showed that congestive heart failure was associated with increased risk of complications and return to the operating theatre (OR 6.83, 95% CI 1.81-25.80) [28]. In asymptomatic patients undergoing carotid endarterectomy (CEA), patients with congestive heart failure have been shown to have an increased risk of post-operative stroke and death [29,30,31]. In a large multicentre national prospective study, congestive heart failure was also a predictor of post-operative myocardial infarction in asymptomatic patients undergoing CEA (P<0.001) [32]. Routine cardiology consultation may be of benefit in patients prior to surgery for asymptomatic CEA to reduce perioperative cardiac complications and mortality [33]. There is no literature to assess the impact of heart failure on the perioperative outcomes of breast surgery.

Heart failure and intermediate risk surgeries:

General surgery:

Heart failure has been shown to be associated with increased hospital length of stay (p<0.04) [34] and mortality (p<0.002) [35] in inguinal and ventral hernia repairs. One prospective multicentre study demonstrated that heart failure was associated with increased rates of wound, pulmonary, urinary tract and cardiac complications following hernia surgery (OR 4.3 95% CI 1.5-12.6) [36]. Heart failure has also been shown to impact on the perioperative and postoperative course of patients undergoing cholecystectomy. Patients with heart failure have been shown to have increased hospital length stays (p<0.001) [37], and increased rates of pneumonia and reintubation (p<0.01) [38,39] and post-operative readmission at 30 days (p<0.0001) [40]. This is the case in both elective and emergency procedures.

Individuals with heart failure who undergo elective laparoscopic sigmoid resection for diverticular disease have been shown to suffer greater perioperative complications including pneumonia, pulmonary embolism, thrombosis, cardiac failure or infarction and renal failure (OR 3.27 95% CI 1.37-7.8 p<0.008) [41]. In a large prospective study assessing the outcomes of bariatric surgery, patients with heart failure have been shown to be more likely to suffer from post-operative DVT and PE [42]. Heart failure is likely to impact on the outcomes of intermediate laparoscopy and laparotomy. A large, prospective, multicentre study revealed that patients with heart failure are more likely to suffer post-operative mortality (OR 3.5 95% CI 2.59-4.63) and complications including haemorrhage, wound, pulmonary, cardiac, sepsis, renal and thromboembolic, following elective left colonic resection, with colostomy or ileostomy for diverticulitis [43]. Post-operative morbidity following elective colectomy via laparotomy for colon cancer has been shown to be significantly higher in patients with heart failure (OR 3.0 CI 95% 1.42-6.32 P=0.003) [44]. Heart failure may also be associated with a higher risk of surgical site infection following laparotomy (OR 1.9 95% CI 1.29-3.04) [45]. In damage control laparotomy, individuals with heart failure may be at higher risk of post-operative mortality (OR 11.4 95% CI 1.01-128.03) [46].

Vascular:

In all vascular procedures, classified as high and intermediate risk, patients with heart failure were more likely to suffer post-operative myocardial infarction [47,48]. Pre-operative cardiac assessment does not appear to improve outcomes [49]. Patients with heart failure may be at increased risk of unplanned 30-day re-admission (OR 1.6 CI 95% 1.1-2.5) [50] and increased mortality (OR 1.62 95% CI 1.32-1.98) [51] following endovascular peripheral angioplasty. In both elective and emergency endovascular aneurysm repair (EVAR), large prospective multi-institutional studies have demonstrated that heart failure is associated with increased risk of postoperative myocardial injury, pneumonia, heart failure, limb ischaemia, renal dysfunction, bowel complications, reoperation, surgical site infection, stroke, prolonged intubation, respiratory complications and discharge to a facility [47,48,51,53,54,55,56,57,58,59]. A large prospective multicentre database study has also demonstrated that heart failure is an independent predictor of mortality in patients undergoing EVAR (P<0.05) [60,61]. Patients who are deemed unfit for open repair of their aneurysm and subsequently have EVAR, commonly have heart failure, and suffer greater post-operative cardiopulmonary complications and perioperative mortality [62]. Patients with heart failure who had a thoracic endovascular aortic repair (TEVAR) have also been shown to be at increased risk of discharge to a facility [63] (p<0.05).

Orthopaedic:

In individuals who underwent surgical fixation for a neck of femur fracture, heart failure was a risk factor for 30-day mortality [64,65,66,67,68,69]. Heart failure was also demonstrated as a risk factor for post-operative complications including: pneumonia (p=0.003) [68]; renal insufficiency (p=0.40) [68]; myocardial infarction (p=0.50) [68]; AKI (p<0.05) [69]; extended length of stay (p<0.001) [68]; and readmission (p<0.001) [68].

Heart failure and high-risk surgeries:

Heart failure is associated with significant morbidity and mortality in patients undergoing major non-cardiac surgery. This is despite advances in perioperative care [27]. Patients with heart failure suffer significantly worse outcomes than those patients with coronary artery disease alone [27].

Vascular:

Whilst there is limited evidence that cardiac testing prior to open abdominal aortic aneurysm (AAA) repair may not improve surgical outcomes in patients, large prospective studies suggest that heart failure is an independent risk factor for post-operative mortality ($p<0.001$) [60,64,70]. Pre-operative heart failure is also associated with post-operative mortality in open thoracic aortic aneurysm (TAA) repair (OR 1.85 95% CI 1.09-3.15 $p=0.03$) [71]. As well as mortality, patients with heart failure suffer increased morbidity, as post-operative major adverse cardiac events after emergency and elective open AAA repair, as well as conversion to open AAA repair from EVAR [56,70,72]. Heart failure has also been shown to be associated with post-operative 30-day readmission ($p<0.05$) [65,73] and increased length inpatient stay ($p<0.001$) [64]. The degree of heart failure, and LVEF, may be proportionate to post-operative morbidity and mortality [70].

Heart failure has also been shown to impact on 30-day outcomes of lower extremity revascularisation. In a large, prospective multi-centre study, patients with heart failure are more likely to suffer post-operative complication rates such as return to the operating theatre ($p=0.022$), prolonged intubation ($p=0.011$), reintubation ($p=0.014$), pneumonia ($p=0.014$), sepsis ($p=0.011$), extended inpatient stay ($p=0.0001$) and mortality ($p<0.0001$) [74]. Subsequent below knee or above knee amputation is associated with increased mortality in patients with heart failure (OR 1.10) [75]. Unfortunately, pre-operative identification of cardiac risk scores does not appear to improve outcomes for diabetic patients undergoing lower extremity revascularisation [76]. Large multi-centre studies have demonstrated that patients with heart failure undergoing infrainguinal bypass are at increased risk of mortality ($p<0.025$) [75,77].

Weakness of Evidence:

Patients with heart failure are likely to suffer additional co-morbidities and it is difficult to ascertain the impact of heart failure on post-operative outcomes alone. Additionally, certain combinations of different co-morbidities may be associated with worse outcomes. The term “heart failure” encompasses a wide spectrum of disease, and undoubtedly certain individuals included in this study will suffer more severe disease than others. Different studies have used different definitions of heart failure (grades of NYHA) and different end points. Additionally, immediacy and pre-operative optimisation will impact outcomes. The purpose of this study however was to perform a general assessment and whilst acknowledging these limitations, demonstrating an overarching trend in the existing evidence.

Conclusion:

Heart failure is a major risk factor for morbidity and mortality in patients undergoing non-cardiac surgery. Morbidity and mortality appear to be consistent from low to high-risk operations. Heart failure is not binary, but exists on a disease spectrum. Operative risk is therefore a combination of factors including: urgency of surgery; degree of heart failure and opportunity for pre-operative optimisation; additional patient co-morbidities; and intraoperative course including blood loss and fluid shifts. Unfortunately, despite preoperative optimisation, patients with heart failure still suffer higher operative risk than those patients without heart failure. Additionally, current guidelines and risk scores classify heart failure as a binary outcome, and do not account for the breadth of disease under this single label.

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Authors’ Contributions:

LC: data collection; data analysis and interpretation; drafting article; approval of final version.

DB: study design; data collection; data analysis and interpretation; revising article; approval of final version.

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