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# Impact of Previous Abdominal Surgery on Open Abdominal Aortic Aneurysm Repair Outcomes

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# ZUSAMMENFASSUNG

**Zielsetzung:**

Die offene Reparatur (Open Surgical Repair: OSR) von Bauchaortenaneurysmen (AAA) stellt für bestimmte Patienten immer noch die beste Option dar, obwohl sich die endovaskuläre Reparatur EVAR in vielen klinischen Zentren zur Option der ersten Wahl entwickelt hat.

Eine erhebliche Anzahl an Patienten, denen zuvor eine andere offene Bauchoperation (previous abdominal surgery: PAS) unterzogen wurde, wird eine OSR für AAA angeboten. Es ist allerdings nicht klar, wie sich die vorherige offene Bauchoperation auf die Ergebnisse der OSR für AAA auswirken kann. Ziel dieser Studie war es, herauszufinden, ob es einen Zusammenhang zwischen PAS und den Ergebnissen der OSR für AAA gibt.

**Methoden:**

Die vorliegende Studie ist eine retrospektive Kohortenstudie, die auf klinischen Daten der Datenbank des „American College of Surgeons National Surgical Quality Improvement Program“ (NSQIP)(34) basiert und alle Patienten einschließt, die sich zwischen 2011 und 2017 einer elektiven OSR bei AAA unterzogen haben. Ausgeschlossen wurden Patienten ohne Daten zu früheren abdominalen Eingriffen, supramesenterialen Klammern oder Patienten mit dringenden Eingriffen (rupturierte oder symptomatische Bauchaortenaneurysmen). Verglichen wurden Patienten mit vorheriger abdominaler Operation (PAS) und Patienten ohne vorherige abdominale Operationen (nonPAS). Das primäre Ergebnis der Studie war die postoperative 30-Tage-Mortalität. Sekundäre Endpunkte der Studien waren die Operationszeit, ischämische Kolitis, postoperative Komplikationen und die Dauer des Krankenhausaufenthalts.

**Ergebnisse:**

Von den 2034 eingeschlossenen Patienten waren 27 % zuvor offen abdominal operiert worden, 73 % nicht. Insgesamt lag das Durchschnittsalter bei 71 Jahren [IQR 65-76], 72 % der Patienten waren männlich, 44 % waren Raucher, und der durchschnittliche BMI betrug 27 kg/m². Eine univariate Analyse ergab keinen Unterschied in der

postoperativen 30-Tage-Sterblichkeit (nonPAS 4.1% gegenüber PAS 4.0% mit p=.91) oder der postoperativen Gesamtkomplikation (nonPAS 29% gegenüber PAS 33% mit p=.07). Eine vorangegangene offene abdominale Operation war signifikant mit längeren Operationszeiten (p=.032) und einer fast doppelt so hohen Rate an ischämischer Kolitis verbunden (nonPAS 2.6% gegenüber PAS 4.7%vs. mit p=.02). Auch die postoperative Intensivstation und der Krankenhausaufenthalt waren bei Patienten mit vorheriger abdominaler Operation signifikant länger (p=.005 bzw. p=.014). Schließlich wurden signifikant weniger Patienten nach Hause entlassen als in ein Betreuungseinrichtung (82.4%nonPAS gegenüber 75.7%PAS, p=.001). Betreuungseinrichtungen beinhalten unter anderem stationäre Rehabilitationszentren, Pflegeheime, Kurzzeitpflege und sekundäre Krankenhäuser. Trotz dieser anfänglichen univariaten Analyseergebnisse erwies sich PAS bei der multivariaten Analyse nicht als statistisch signifikanter unabhängiger Risikofaktor für die 30-Tage-Mortalität, die ischämische Kolitis oder längere Operationszeiten.

**Schlussfolgerung:**

Diese Studie deutet darauf hin, dass Patienten, die sich einer PAS unterzogen haben, einige Nachteile bei der OSR von AAA haben können. Diese negativen Trends gehen jedoch nicht so weit, dass PAS statistisch signifikant als unabhängiger Risikofaktor für 30-Tage-Sterblichkeit, ischämische Kolitis oder längere Operationszeiten identifiziert werden kann. Daher schlagen wir vor, dass eine frühere offene Bauchoperation kein alleiniger Grund dafür sein sollte, Patienten davon auszuschließen, für eine offene Aortenaneurysmareparatur berücksichtigt zu werden.

## ABSTRACT

**Objective:**

Choosing between endovascular aortic repair (EVAR) and open surgical repair (OSR) for the treatment of abdominal aortic aneurysms AAA is still a contemporary issue. Finding which patients are still better suited to OSR continues to challenge vascular surgeons. One perceived risk factor for OSR is previous open abdominal surgery (PAS), something an increasing number of patients present with. This study aims to investigate if this perception is justified. The aim is to determine if and if so to what extent there is an association between PAS and outcomes of OSR for AAA.

**Methods:**

This study retrospectively analysed data from 2011-2017 in the NSQIP database (National Surgical Quality Program) created by the American College of Surgeons. All patients registered in the OSR for AAA were screened for inclusion. Exclusion criteria were emergency repairs, clamp-level above the Truncus Coeliacus and cases with missing data in the subject of this research (no entry in prior abdominal surgery PAS variable). Outcomes of the study were targeted towards clinically relevant outcomes of OSR of AAA, including as a primary outcome the 30day postoperative mortality and as secondary outcomes: operating time, ischemic colitis, postoperative complications, and lengths of hospital stay.

**Results:**

The total study population was N=2034 patients, of which almost one third (27%) had undergone prior open abdominal surgery (PAS group) while 73% had not (nonPAS). In total there were 72% men and 28% women with an average BMI of 27 kg/m². The median age was 71yo with an IQR of 63-76 years old. Also, 44% of the study population were smokers. The primary outcome of 30day mortality showed no difference between the groups on univariate analysis (4.0% PAS vs 4.1% nonPAS, p=.91), and multivariate analysis showed concurrent findings. A significant association was found in univariate analysis for the secondary outcomes of longer operating times (p=.032) and rate of ischemic colitis (4.7% PAS vs 2.6% nonPAS, p=.02). However these results were not confirmed on multivariate analysis, finding

instead that PAS was not an independent risk factor for 30day mortality, operating time nor ischemic colitis.

Other univariate analyses showed significantly longer postoperative hospitalisation and time in intensive care (p=.014 and p=.005 respectively). Also the discharge back home (vs to other care facilities) was 6.7% less in the PAS group (p=.001).

**Conclusion:**

There are some negative trends in the outcomes of patients that have undergone previous abdominal surgery vs those that have not, except for 30day mortality most univariate analyses show worse outcomes for OSR after PAS. Multivariate analysis on the other hand show that PAS in and of itself is not an independent risk factor for the mortality, ischemic colitis or longer operating time. For this reason, we suggest that PAS in and of its own should not be considered as a prohibitive risk factor in the selection of patients for eligibility of open aortic abdominal aneurysm repair.

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# ABBREVIATIONS

AAA: Abdominal aortic aneurysm

OSR: Open Surgical Repair

PAS: Previous open abdominal surgery

nonPAS: non previous open abdominal surgery

ACS: American College of Surgeons

NSQIP: National Surgical Quality Improvement Program

SCR: Surgical Clinical Reviewer

ICU: Intensive Care Unit

EVAR: Endovascular Aortic Repair

AMI: Acute myocardial infarction

IQR: interquartile Range

SPSS: Statistical Product and Service Solutions

SSI: Surgical Site Infections

PAD: Peripheral Arterial Disease

OP: Operative

QALY: Quality of Life Years

IMA: Inferior Mesenteric Artery

SMA: Superior Mesenteric Artery

COPD: Chronic Obstructive Pulmonary Disease

CHF: Chronic Heart Failure

UTI: Urinary Tract Infection

CPR: Cardiopulmonary Resuscitation

# 1. INTRODUCTION

## a. Historical Background

An abdominal aortic aneurysm (AAA) is defined as a broadening or dilation of the aortic vessel diameter to over 1,5 times the normal diameter (2). Currently a threshold of 30mm is universally used to define an AAA, and treatment thresholds according to latest guidelines (3) are at 55mm for men and 50mm for women.

Historically abdominal aortic aneurysms have been feared by patients and surgeons alike, with rupture rates resulting in high mortalities. The first successful open surgical treatment with aortic graft placement was reported by Charles Dubost in 1951 (4). Following this DeBakey developed the first Dacron grafts in 1954, and these have since been refined and standardised to form the same grafts in use today (5). While surgical standards have gradually modernised and improved, the basic procedural steps to an open surgical repair (OSR) of infrarenal abdominal aortic aneurysms have largely remained the same.

The invention of endovascular therapy is generally accredited to Charles Dotter in 1964, with the first angioplasty of a stenotic superficial femoral artery. Following this, Nikolai Volodos (Ukraine) reportedly developed and successfully implanted the world's first endovascular aortic repair (EVAR) in 1987 (4). After development of a unibody bifurcated stent graft system, first used in Aachen 1993, industry became gradually involved in making increasingly standardised stent systems for the infrarenal abdominal aorta. Since then ever-more sophisticated grafts have been developed including branching and fenestration to cater to an ever-expanding range of aortic aneurysmatic disease.

## b. EVAR vs OSR – Tailored Approach

As EVAR technology has grown and improved over the past decades it has become a first line strategy in the modern medical world. Indeed technically the success rates have reached such levels that there are few anatomical & clinical situations left in which EVAR is not a potential option. However comparing not only technical success rates but also short- and especially long-term outcomes of EVAR vs OSR have been the basis of extensive scientific study and debate over the last 20 years. Renowned trials such as EVAR 1, DREAM, OVER and ACE trials have focussed on this clinical problem (7-10). A meta-analysis of these trials published in 2017 by J.Powell et al (11) reiterated findings that early survival in EVAR vs OSR was subject to a patient's subgroups, depending on comorbidities such as PAD and renal insufficiency. Also that long-term results were generally still in favour of OSR.

The contemporary view is that a tailored approach is the best strategy, each patient individually should be considered for both OSR and EVAR. For some patients OSR remains the treatment of choice (12-14). Favourable long term results especially in elective settings and younger patients (15,16) have led to a situation where nowadays about 1/5 of AAAs are being treated by OSR in the USA (17). The clinical problem that vascular surgeons face today is making that decision in an evidence based way. Which patients are truly suited best to EVAR and which to OSR. Broadly, it is in this space, that the research presented in this dissertation aims to contribute.

## c. Epidemiological Trends

Recent epidemiological trends have seen a decrease in the overall prevalence and incidence rates of AAA (18,19). Amongst others, the UK National screening program has published data related to this (20). In 2009-2013 the program reported a 1.3% AAA prevalence in the screening population (all men >65yo), while the 2020-2021 rate has dropped <1%. This change has been recognised internationally so that the 2024 guidelines have changed to targeted screening for at risk populations. This decrease has been largely attributed to improved quality and adherence to best medical care (including statins and antihypertensive medication), and a decrease in smoking rates in the >65y population categories (3).

Despite this, the actual number of AAA repairs offered on a global scale is likely to continue to increase. As improving healthcare access and quality coincides with an aging global population (21), vascular surgeons around the world will increasingly face the decision making moment of OSR vs EVAR.

## d. Risk prediction models

The challenging and relevant question for the modern vascular surgeon is indeed selecting those patients that in fact would still be better suited to open surgical repair. Differentiating between 'low risk' vs 'high risk' factors (15) for both EVAR and OSR is increasingly relevant and necessary to shape risk prediction models.

The existing risk prediction models include the "Vascular Quality Initiative Mortality risk score" (22), the "Glasgow Aneurysm score" (23), and the "modified Leiden score" (24). These models primarily use patient renal and/or cardiovascular comorbidities. They stem largely from data reported in retrospective studies (25-27) statistically designed to determine predictive risk factors within patients already treated by OSR. This however does not take into account how patients were originally picked for OSR vs EVAR to begin with.

In prospective studies, including the prominent EVAR-1 and EVAR-2 landmark papers (7, 28) surgeons were given the option to exclude patients from consideration for OSR based on their judgement of a patient 'unfit' for open surgery. Surgeons were free to define a patient or indeed abdomen 'unfit' for open surgery. Incidentally, subsequent research has suggested that these patients deemed "unift for open repair" went on to have poor outcomes after endovascular repair as well. (29)

Cardiovascular and renal comorbidities that would render a patient unfit for open repair, have already been described and incorporated into contemporary risk prediction models for AAA patients (22-24). Besides these, surgeons may also deem a patient unfit because their abdomen is 'unfit'. One reason is previous abdominal surgery, particularly multiple or extensive surgery, after which a more difficult access to the aortic aneurysm is anticipated (28,30). This baseline patient characteristic is as yet not incorporated into published risk prediction models, although repeatedly encountered in daily clinical practice.

## e. Previous Abdominal Surgery as a Risk Factor

Any open abdominal surgery with entry to the intraperitoneal space is technically considered an 'injury' to the abdominal cavity. Along with septic or traumatic injury, abdominal surgery necessarily triggers an inflammation reaction in the peritoneum (31). Cellular and acellular inflammatory mediators initiate the tissue repair process and regeneration of the peritoneum, starting with remesothelialization. After one week the acute inflammatory phase is complete with fibroblast differentiation, collagen deposition in the extracellular matrix and activated neoangiogenesis. In the weeks and months following this some patients will develop permanent adhesions in the abdomen. These are fibrous strands between abdominal organs due to which future access to the abdominal space is more difficult. Which patients develop adhesions, why, and to what extent is still largely unknown and forms an extensive field of research (32). Patients with extensive and repeated abdominal surgery may develop a status known as a 'hostile abdomen' in which adhesions are so extensive that surgical manoeuvring in the abdomen becomes very dangerous and requires time consuming adhesiolysis. It is a diagnosis that is sometimes difficult to predict preoperatively thus, often posed intraoperatively.

In the field of general surgery this issue has been studied, in abdominal laparoscopic surgery for instance, researched have developed a risk score called the "Hostile Abdomen Index" (33). The score uses preoperative criteria including number of previous abdominal surgies as well as intraoperative criteria ranging from omental adhesions to massive diffuse adhesions. There is no such scoring system in the field of vascular surgery. The evidence of the effect previous abdominal surgery may have on outcomes of open surgical repair is largely lacking. However, vascular guidelines, particularly the standing American society for vascular surgery guidelines (22) recommend: "a retroperitoneal approach for patients … requiring OSR of an aortic aneurysm in the presence of … a hostile abdomen". This recommendation level is strong (level 1) although the Quality of evidence is low (C). There is clearly recognition of the danger of previous abdominal adhesions to OSR of AAA, despite the discrete body of research available. This perceived danger explains why previous history of abdominal surgery alone, is sometimes considered an incentive for clinicians to choose EVAR over OSR. Studies proving that previous abdominal surgery is

associated to inferior results of OSR for AAA are lacking, this is the main focus of the research presented here.

## f. Aims and Hypotheses

The aim of this research is to explore the association between previous open abdominal surgery (PAS) and the results of open surgical repair (OSR) of abdominal aortic aneurysms (AAA). And subsequently, to determine if PAS is an independent risk factor for mortality and morbidity of OSR.

The hypothesis is that PAS of any kind is negatively associated with mortality and morbidity of open AAA repair. If this is true, previous abdominal surgery (PAS) in and of its own should be considered in the development of future risk prediction models and decision making algorithms for tailored treatment strategies of AAA.

# 2. MATERIALS AND METHODS

## a. Overall Study Design

The study design chosen was a retrospective cohort study using data extraction and analysis from an international database called NSQIP (see 2b). Registries for open surgical repair (OSR) of Abdominal Aortic Aneurysms (AAA) between 2011 and 2017 were analysed. In total 2034 patients were included in the overall study Population (see 2c). The primary outcome was death from any cause within 30days postoperatively. The secondary outcomes included intraoperative factors such as operating time, postoperative complications divided into surgical and overall with an extra focus on ischemic colitis, and lastly the time of admission in intensive care and in hospital overall (see 2e 'lengths of stay'). After descriptive analysis of the population, univariate analysis and multivariate analyses were performed for the predefined outcomes (see 2g). Before commencement of data collection ethical approval was officially stated as unnecessary by the "Ethikkomission bei der LMU München" (see 2b & Appendix 1).

## b. NSQIP Database

SOURCES: "American College of Surgeons National Surgical Quality Improvement Program" (34). The NSQIP database is an initiative from the United States of America, and as the ‚N' for National suggests the initial participating centres were all located in the USA. However as the registry has grown and accepted more centres, there are currently 677 hospitals contributing internationally (34). Each year the list of participating hospitals are published on the American college of Surgeons website (35).

DATA COLLECTION: Data is collected and entered into the database by "certified surgical clinical reviewers" only for "quality control purposes" (34). These surgical clinical reviewers (SCR) are required to meet training standards and are re-certified yearly. With patient consent, SCR's are authorized to gather the requested NSQIP variables, using medical chart abstraction. Anonymised patient variables are entered into the ACS NSQIP website. Additional quality control is gained by regular Inter-Rater Reliability Audits further explained in the 2017 NSQIP user guide (34).

Data sampling requirements are individualised to participating centres. Smaller, rural centres may be required to collect all eligible cases, while larger centres have minimal sample size requirements. To avoid sampling bias a systematic sampling process has been developed in which 8-day sampling cycles are set up, 8 days in which all eligible cases must be registered. Again for more details see the NSQIP 2017 user guide (34).

The database has grown to include over 300 variables per entry. These vary from demographic data to patient comorbidities, and most of all a series of postoperative outcomes recorded up to a limit of 30 days. There is no further follow up data collection possible after the 30day postoperative mark. The aforementioned NSQIP user guide is published yearly (34) for all participating centres and publishing authors to use. This has listed and stated definitions for all of the variables included in the data collection. For a complete list of recorded variables in the NSQIP database see Appendix 2.

ACCESS: Any author, whether it be from a participating centre or not has the right to request access to the NSQIP database for research purposes. The research of this dissertation was performed in cooperation with Drs Bacharach T and Dayama A from the following NSQIP-participating centre: Sanford USD Medical Centre and Hospital, Sioux Falls, SD, USA. At the time of conception of the research methods (October 2020) NSQIP Registry data was available and authorized to perform research on for the years 2011 to 2017.

ETHICS APPROVAL: Before accessing the available NSQIP database this research project was presented to the “Ethikkomission bei der LMU München” in October 2020. The requirement to download and analyse the anonymized patient data from the database was explained including the aforementioned aim, hypothesis, primary and secondary outcomes. This research was deemed to conform to the requirements of what the Ethics commission categorises as clause 1.4: “Analysis of existing data” (36). For this reason a more extensive control of the study’s protocol-plan and commission approval was waivered: “Keine Beratungspflicht”. This document is included in Appendix 1.

## c. Study Population: Inclusion & Exclusion criteria

This research used the NSQIP entries between 2011 to 2017, specifically selecting the AAA dataset that was registered under OSR. All NSQIP data adheres to an exclusion of underage patients (<18) or clinically brain-dead patients (ASA 6) (37). Other NSQIP case or hospital exclusion criteria pertain mainly to avoiding multiple registrations of each patient and to quality assurances. This list is exhaustively included in Appendix 3. All NSQIP entries for OSR of AAA between 2011 and 2017 were extracted. The initial case number was N=3941. This data was first analysed for completeness. Cases with missing data in the variable previous open abdominal surgery (N=382) were excluded, leaving N=3559 patients. This study focus was elective repair, for this reason emergency cases were excluded. Supra-mesenteric clamping was also considered incomparable (as explained hereafter) and therefore excluded. The total selected study population was therefore N=2034. Figure 1: Selection of study Population.

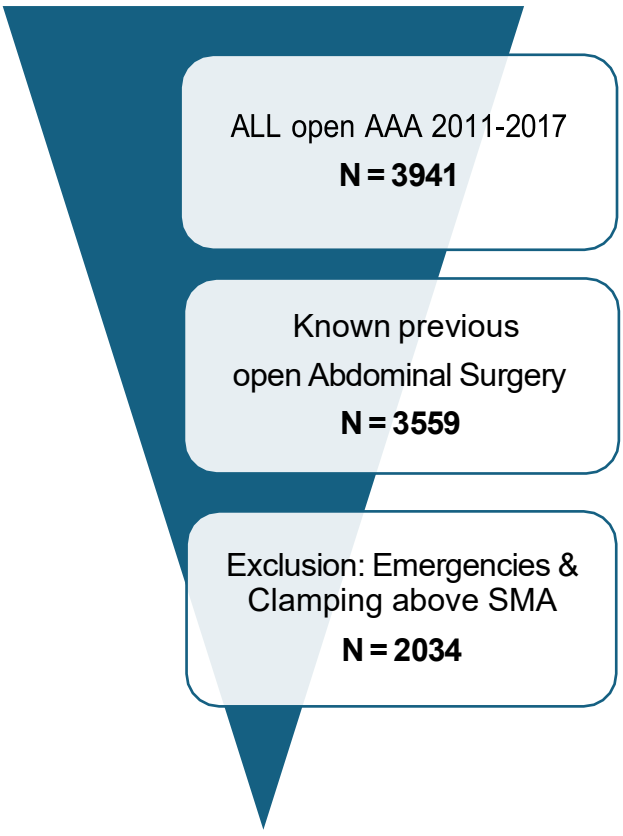


*Figure 1 Selection of the Study Population*

The reasoning for excluding emergencies was clinical relevance and comparability. Urgent repairs are not met with the same benefit of tailored clinical decision making, and have much higher mortality and morbidity (38) that would not be comparable to outcomes in the elective setting.

Similarly, the level of aortic clamping influences intraoperative outcomes as well as postoperative mortality and morbidity (39, 40). Suprarenal clamping is associated with renal hypoxia and thus increased acute kidney failure postoperatively as well as increased overall postoperative mortality in patients with acute on chronic renal insufficiency(41). Supramesenteric clamping is associated with hepatic and mesenterial ischemia, but also causes extensive hemodynamic disturbances and cardiopulmonary compromise (40). Moreover exposure of the supramesenteric section of the Aorta requires considerably higher exposure of the aorta. This markedly more extensive level of surgical dissection and hemodynamic impact on the patient was deemed incomparable to cases without supramesenteric clamping.

However choosing the level of aortic clamping to include was subject to close examination. To a certain extent this factor may be on the causal pathway between prior abdominal surgery and outcomes of OSR. Indeed, the hypothesized adhesions or even hostile abdomens may be the reason that more proximal clamping is required, therefore contributing to the effect of PAS on outcomes. Excluding all suprarenal cases may, in part, conceal the effect this research aimed to study. After careful deliberation with the research team, exclusion of cases with supramesenteric clamping was deemed appropriate and necessary while inframesenteric clamping (be it infra- or suprarenal) was included.

Separately from level of clamping the NSQIP dataset also provided variables pertaining to the Aneurysm extent. The proximal extent options were infrarenal, juxtarenal, pararenal, suprarenal and thoracoabdominal. Distal extent outputs were aortic, common iliac, internal iliac and external iliac. While excluding supramesenteric clamping would presume to exclude all cases of thoracoabdominal aneurysms this was actually not the case. As only 3% of the study population was reported as TAAA, it was considered unnecessary to exclude these cases. Also it could be possible that, for whatever reason, these very few patients might have undergone inframesenteric aortic repair despite technically having aneurysms that reach higher. As this would

not affect the impact PAS would have on outcomes. Therefore it was not necessary to exclude these patients.

## d. Data Management

NSQIP Database contents were downloaded and made accessible per year 2011 to 2017, resulting in 7 standardised but separate excel data files as raw data for this research. All data received was anonymised and stored in password locked protected university hospital servers, with access specifically for research team participants.

The variables collected in NSQIP actually varied by year with tendency to increase over time. A more uniformed version of variables started in 2016. When merging the separate years it was necessary to choose variables that had been recorded throughout the study time and limit the overall number to those deemed relevant for the purpose of our study. In total 346 variables were collected in the raw data points, of these a total of 121 were selected (full list available in Appendix 4). Additionally 16 variables were created using already available data. A full account of these and their formula or method for defining is also included in Appendix 4.

All Data was transferred to the statistical software program called SPSS (statistical product and service solutions). The individual case files from 2011 to 2017 were merged into a single data set, and standardised using the 121 selected variables. As described above, the exclusion criteria were used to filter the desired study population. All further statistical analysis as described below was performed in SPSS.

## e. Outcomes and Variables of Interest previously published (1)

Demographic data from the NSQIP database and selected for this study included gender, age, weight (calculated into BMI) and smoking status. Comorbidities selected from the NSQIP data list for inclusion into this study included COPD (chronic obstructive pulmonary disease), diabetes mellitus, arterial hypertension, preoperative steroid intake and disseminated cancer. Additional data included dialysis status, whether patients had preoperative ascites, sepsis, or known bleeding disorders.

Although supramesenteric clamping was excluded in case selection, supramesenteric disease was included in aneurysm parameter variables. Other aneurysm measurements that selected for the study were distal extent and maximum diameter. Operating time was chosen as the main intraoperative variable of interest. Other intraoperative variables included: surgical approach (retro or transperitoneal), proximal clamp location, renal revascularisation, visceral revascularisation, and management of inferior mesenteric artery.

The primary outcome of the study was 30-day death from any cause. Other postoperative variables selected for study were surgical and non-surgical complications (categorised in Table 1), lengths of stay (hospital overall and on intensive care unit separately), and lastly discharge destination home vs other institutional care (as an indicator of the patients' overall wellbeing extending beyond the 30day recording cutoff postoperatively).

## f. Key Variable Definitions

PREVIOUS ABDOMINAL SURGERY:

Variable label AAA_PAAS

NSQIP Surgical Clinical Reviewers were instructed to enter the variable "PAS" defined as preoperative open abdominal surgery, possible entries were "yes" "no" or leaving the question blank. Any open abdominal surgery be it open appendectomy, inguinal hernia repair, or more extensive complex surgery such as colectomies, adhesiolysis or even Whipple operations were treated equally and would warrant a "yes". The type of previous surgery and the number of previous operations was not recorded in the NSQIP database.

Previous abdominal surgery was the variable of interest, the independent variable of the study.

POSTOPERATIVE MORTALITY:

Variable Label MORT30D

Postoperative mortality according to NSQIP and thus for the purpose of this study, was defined as death from any cause, intraoperatively or within 30 days. Deaths related to AAA, including postoperative rupture, as well as deaths unrelated to the AAA such as AMI (acute myocardial infarction) or septic shock were treated equally and be recorded as an event.

Original NSQIP Data recorded a variable labelled “DOPERTOD” defined as days from operation to death. This variable was converted to the created variable MORT30D including any death recorded, as data collection stopped after 30days, all recorded deaths fall into the defined outcome of 30day postoperative mortality. The postoperative complications leading to the death of the patient were also recorded and analysed separately cf.infra.

Postoperative mortality was the primary outcome of the study.

ISCHEMIC COLITIS:

Variable Label: “AAA_COLITIS”

Ischemic colitis was recorded in the NSQIP Database as a ‘yes’ or ‘no’ output (AAA_COLITIS). Additionally the number of days postoperatively that ischemic colitis was treated was also recorded (AAADCOLITIS). Thirdly, the course of treatment was recorded (AAA_COLITIS_TREAT). Treatment options to select were either “conservative”, “surgical” or blank.

How this diagnosis was made is not included in the recordings of NSQIP. In the NSQIP handbook the diagnosis parameters were left up to the participating centres asking simply for a yes or no output. Ischemic colitis is known to be a difficult clinical diagnosis (42), some cases are mild and transient and may go undiagnosed. Equally some misdiagnoses should also be taken into account because there is a broad differential diagnosis and validation through CT or coloscopy was not necessary for diagnosis. In order to ‚test‘ the validity of the ischemic colitis entry point we cross-checked the registered treatments with the ischemic colitis cases. Of the N65 patients that developed ischemic colitis (3.2%) all but 3 had valid treatment allocations.

Interestingly 28 were categorised as medically treated and the remaining 34 were treated surgically. As the self-created ‚validity' check was hardly differing from the raw data set it was deemed preferable to take on the ischemic colitis output variable as registered in the raw data with no manipulation for further analysis.

Ischemic colitis was a secondary outcome of the study.

POSTOPERATIVE COMPLICATIONS:

Postoperative complication was a secondary outcome of the study.

Relevant postoperative complications were selected for the study and carefully categorised into surgical and non-surgical (Table 1).

*Table 1: Postoperative Complications, Categorisation of the Variables, this table is modified from Bertrand et al. (1)*

| Postoperative Complications | |
|---|---|
| **Surgical** | **Non-surgical** |
| Surgical site infection | Acute myocardial infarction |
| Wound disruption | Cardiac arrest requiring cardiopulmonary resuscitation |
| Ischemic colitis | Cerebrovascular accident or stroke with neurological deficit |
| Lower extremity ischemia | Pneumonia |
| Postoperative aneurysm rupture | Deep vein thrombosis or thrombophlebitis |
| Acute renal failure | Progressive renal failure |
| Postoperative bleeding | Pulmonary embolism |
| | Urinary tract infection |
| | Sepsis |

- SURGICAL SITE INFECTION:

Variable Label “Any SSI”

A variable was created to pool all entries that would qualify as surgical site infections. “Any SSI”. This included all entries for “superficial surgical site infection”, “deep surgical site infection”, or “organ space site infections”(34). Each of these were also kept as separate variables and reported on separately as well.

- POSTOPERATIVE BLEEDING:

Variable Label “PO_BLEED”

The NSQIP Database provided a variable labelled ‘OTHBLEED’, defined as Occurences Bleeding Transfusions, meaning the number of transfusions this patient received. However, intra vs postoperative transfusions were not kept separate in every year’s recording.

Postoperative bleeding was hypothesised to potentially be an important factor on the causal pathway of PAS affecting outcomes. That is to say increased intraabdominal scarring and thereby more challenging dissektion planes and/or extraanatomical vascular beds might be a reason for unexpected bleeds that could impact the main study outcomes. For this reason, it was felt valuable to maintain this information.

Defining postoperative bleeding as ‚any patient requiring transfusion‘ would have been considered rather too large and is not a good indication of an actual postoperative complication. As not all years included data of how many units of blood were given at which point in time, it was decided to use the available variable of the day of transfusion.

A variable was created to record postoperative bleeding by this definition, labelled “PO_BLEED”. This combined information from the previously mentioned OTHBLEED variable and another variable labelled “DOTHBLEED”. The latter was defined as days from operation until bleeding/transfusions complication. Any cases with valid entries in the OTHBLEED variable AND with an entry 1 or above in the DOTHBLEED variable was included as a postoperative bleed (“yes” for PO_BLEED).

For further details of other postoperative variable definitions see Appendix 1 & 4 or refer to the ACS NSQIP 2017 User guide (34).

<u>OPERATING TIME:</u>

Variable Labels “OPTIME” and “OPTIMEMED”

NSQIP data provided each case with an operating time recorded in minutes under the variable label OPTIME. For the purposes of further statistical analysis it was useful to categorise this data into high or low operating times, which was defined as above or

below the median operating time: 230minutes. This variable was created and labelled OPTIMEMED. The median was used because the distribution of operating times was found to be non-normal (see 2g).

Operating Time was a secondary outcome of the study.

LENGTH OF STAY:

Variable Labels “TOTHLOS” and “AAA_ICULOS”

More extensive surgery potentially caused by PAS and subsequent adhesions in the abdominal space may be difficult to measure in cases that did not develop over postoperative complications. However we hypothesized that extensive surgery was likely to require longer healing times for patients and likely require longer hospital stays. This data was available in NSQIP in the form of two variables; overall length of hospital stay measured in days “TOTHLOS” and length of intensive care unit stay also measured in days “AAA_ICULOS”.

Length of stay variables were secondary outcomes of the study.

DESTINATION DISCHARGE:

Variable Label “DESDISCHPOOL”

Similarly more extensive surgery is likely to have a larger impact on the overall postoperative status of the patient. This might include reduced mobility of the patient, increased frailty, or reduced independence. These impacts would matter greatly to a patient and be very much considered as part of the success rating a patient might give an intervention, no matter how technically successful or which postoperative complications were or were not avoided (43). To capture the effect of extended surgery after the 30day cut-off, destination of discharge was a meaningful parameter. The NSQIP Database recorded the destination of discharge allowing for a variety of entries ranging from secondary hospitals, inpatient physiotherapeutic centres, and elderly homes. For the purpose of this study a new variable was created DESDISCHPOOL to simplify the analysis to patients that went home vs those that did not. All entries that were any form of additional post-discharge institutionalised care

were pooled into a “no” entry while all entries that meant patients were discharged to their preoperative home were entered as “yes”.

Destination discharge was a secondary outcome of the study.

## g. Statistical Analysis

All statistical analyses tests were done using the complete population study set in the SPSS software program.

DESCRIPTIVE ANALYSIS:

The overall study population was analysed for descriptive features, both the PAS and nonPAS groups together. This included baseline demographic and comorbidity data, as well as aneurysm parameters. Categorical variables were reported in proportions or percentages. Continuous variables were proofed for normal distribution with a Kolmogorov-Smirnov test requiring $p>0.05$. Measures of central tendency for normally distributed variables were averages and standard deviations. Measures of central tendency for non-normally distributed variables were medians and interquartile ranges.

Next these descriptive variables were analysed for the PAS and nonPAS groups separately. So as to determine baseline comparability of the groups the differences of the group’s characteristics were statistically tested for significance. While Chi-squared testing was used for categorical variables, t-testing or Mann-Whitney U testing were used for continuous variables depending on their distribution (normal or non-normal respectively). After detailed deliberation of the results of this initial descriptive analysis the groups PAS and nonPAS were deemed similar enough at baseline so that propensity score matching was considered unnecessary and inappropriate.

UNIVARIATE ANALYSIS

Next, the predefined primary and secondary outcomes were subject to univariate analysis. Once again categorical variables were analysed with Chi-squared testing and continuous variables were analysed with Student-T tests or Mann-Whitney U tests (for normal or non-normal distributions respectively). As before, normality of variables was checked with the Kolmogorov-Smirnov test.

MULTIVARIATE ANALYSIS

To examine the independent variable (PAS) as an independent risk factor for the outcomes multivariate analysis was required. A multivariate logistic regression analysis was chosen for the 30 day postoperative mortality (as primary outcome of the study). All variables with an association to this outcome with a significance $p<0.2$ were included in the regression model.

The secondary outcomes of ischemic colitis and operating time were also subject to multivariate analysis. Again a logistic regression in stepwise fashion was performed and once more all variables with an association to the outcome on univariate analysis with $p<0.2$ were included.

The research team refrained from performing repeated/multiple multivariate analyses on the other secondary outcomes in order to avoid significance fishing.

SUPPLEMENTARY ANALYSES

- MALE PATIENTS ONLY:

As previously discussed (2f), the definition of the independent variable PAS included any open abdominal surgery. Previous gynaecological surgery such as C-sections and open Hysterectomies were also acceptable as a prior abdominal surgery. For this reason it was considered necessary and appropriate to validate the main findings of the study using male patients only. The Univariate and Multivaraite regression analysis was repeated in the exact same way as described above for the following outcomes: 30day mortality, ischemic colitis, and OP Time.

- TRENDS OVER TIME:

To determine if prior abdominal surgery was likely to be an increasing problem for patients with AAA facing treatment, a series of additional analyses was performed to explore the trends over time. The purpose of this was to better contextualise this research and use the existing data to further inform future research exploring this space. Proportions of PAS were reported for each year 2011-2017 separately. Similarly percentages of 30D mortality, ischemic colitis, discharge destination and surgical approach were chosen as variables of interest to report separately for each year.

# 3. RESULTS

## a. Descriptive Analysis : Table 2

The study included 2034 patients with 28% female and 72% male. Almost a third (27%) had undergone prior abdominal surgery (PAS group), while 73% were reported not to (nonPAS). Patients without valid entry for previous open abdominal surgery had been excluded from the study (cf. supra). The median age was 71 years old with an IQR of 65-76, the mean BMI was 27.6 ± 5.6 and 44% were smokers. Unsurprisingly most patients had some form of cardiovascular comorbidity additional to these risk factors. Besides 80.5% having arterial hypertension, 19% had COPD, 12.5% had diabetes mellitus, and 1.5% suffered from chronic heart failure.

The first comparative analyses of the groups PAS vs nonPAS are presented in Tables 2a-c below. The PAS group had a median age 2 years above the nonPAS group (72 vs 70, p<.01), with significantly more female patients (42% vs. 23%, p<.01) and a higher ASA Score (42% ASA III or more PAS group vs 36% in the nonPAS group, p = .04). However, as a measure of a patient's overall wellbeing and independence before OSR of AAA, the "functional status" variable showed no significant difference between the groups (97% functionally independent in PAS vs. 98% in nonPAS. p = .08).

Aneurysm parameters overall and in PAS vs nonPAS are displayed in Table 2c. Aneurysms were generally comparable, with maximum aneurysm diameter of 58mm as a median of the whole study population but also of both groups. Although distal extent with common iliac involvement was less in the PAS group (52% vs 54%) further extension into the externa iliac was more in the PAS group (12% vs 8.2%).

All the differences in demographic, comorbidity and aneurysm parameters are presented in tables 2a-c (1). The only remaining differences between the groups were small in absolute value (6% maximum) and/or not significant on p-value. For this reason the groups were considered comparable to permit further analysis.

| Descriptive Analysis 2a. Demographics | | | | |
|---|---|---|---|---|
| | **Overall N:2034=100%** | **Non PAS 73%** | **PAS 27%** | **Difference p-value** |
| **Gender M:F %** | 72:28 | 77:23 | 58:42 | **<0,01** |
| **Age median*** | 71 | 70 | 72 | **<0,01** |
| **BMI** | 27 | 27 | 27 | 0,94 |
| **ASA >III %** | 38 | 36 | 42 | **0,04** |
| **Functional Status (% independent)** | 98 | 98 | 97 | 0,08 |
| **Smoker %** | 44 | 46 | 42 | 0,13 |

*Table 2a. Descriptive analysis overall and comparing the groups Focussed on Demographic data. Table modified from previous publication by Bertrand et al (1). "* as the NSQIP database codes all ages above 90 as 90, this result is potentially skewed to be slightly younger than reality" (1).*

| Descriptive Analysis 2b. Comorbidities | | | | |
|---|---|---|---|---|
| | **Overall N:2034=100%** | **Non PAS 73%** | **PAS 27%** | **Difference p-value** |
| **CHF** | 1,5 | 1,3 | 2 | 0,29 |
| **Severe COPD** | 19 | 17 | 23 | **<0,01** |
| **AHT** | 80 | 79 | 82 | 0,27 |
| **DM** | 13 | 13 | 14 | 0,41 |
| **Ascites** | 0 | 0,1 | 0 | 0,54 |
| **Dialysis** | 0,8 | 0,5 | 1,5 | 0,04 |
| **Disseminated Cancer** | 0,3 | 0,3 | 0,5 | 0,35 |
| **Sepsis/SIRS** | 2 | 1,9 | 2,9 | 0,06 |
| **Bleeding disorders** | 7,1 | 6,4 | 8,9 | 0,05 |
| **On Steroids** | 3,4 | 2,8 | 5 | **0,01** |

*Table 2b. Descriptive analysis overall and comparing the groups Focussed on Comorbidities. Table modified from previous publication by Bertrand et al (1).*

| Descriptive Analysis 2c. Parameters of the Abdominal Aortic Aneurysm | | | | |
|---|---|---|---|---|
| | **Overall N:2034=100%** | **Non PAS 73%** | **PAS 27%** | **Difference p-value** |
| **Maximum Diameter mm group median** | 58 | 58 | 58 | 0,50 |
| **Proportion Infrarenal % (vs juxta/para/suprarenal)** | 58 | 59 | 57 | 0,26 |
| **Proportion Iliac involvement % (subgroup external iliac involvement %)** | 53 (9) | 54 (8,2) | 52 (12) | **0,01** |

*Table 2c. Descriptive analysis overall and comparing the groups focussed on Parameters of the Aneurysm. Table modified from previous publication by Bertrand et al (1).*

## b. Overall 30day Postoperative Outcomes: Tables 3a - c

The predefined primary outcome, all cause 30-day mortality, was 4.1% overall and 4.1% in the nonPAS group vs 4.0% in the PAS group. This small difference was not statistically significant (p=0.91).

Overall the 30day postoperative complication rate was 30%, slightly more in the PAS group 33% vs nonPAS 29% (p=0.07). Proportionately this was largely caused by surgical complications: 21% overall vs. the overall 9% non-surgical complication rate. Of the surgical complications by far the most prevalent was bleeding (68.1%). Next in frequency was ischemic colitis (3.2%) and acute renal insufficiency (3.2%). The less frequent postoperative surgical complications were acute lower extremity ischemia (1.8%), wound disruption (1.3%) and rupture within 30days (0.5%). Surgical site infection was broken down into superficial 1.4%, deep 0.4%, or organ space 1.0%. Of the non-surgical complications the most prevalent were pneumonia (6%) and myocardial infarction (3.3%).

As previously mentioned there was no significant difference between PAS and nonPAS in the overall complication rates. In the category of surgical complications only, there was even less of a difference between the groups (22% PAS vs 21% nonPAS, p =0.65). In Table 3b the breakdown of all surgical outcomes and their differences between the PAS and nonPAS groups are shown. There was a statistically significant difference in postoperative bleeding rates (71.6% PAS vs 66.8% nonPAS p = .04) and ischemic colitis rates (4.7% PAS vs 2.6% non PAS p = .02). Other surgical complication rates were not statistically significantly different between the groups.

In Table 3c the breakdown of all non-surgical outcomes and their differences between the PAS and nonPAS groups are shown. Except for the UTI rates (PAS 4.2% vs nonPAS 1.6% p<.01) there were no statistically significantly differences between the groups.

| 3.a Overview of the Main Outcomes | | | | |
|---|---|---|---|---|
| | **Overall N:2034=100%** | **Non PAS 73%** | **PAS 27%** | **Difference p-value** |
| **30Day all-cause Mortality %** | 4,1 | 4,1 | 4,0 | 0,91 |
| **Operating Time median** | 230 | 227 | 237 | **0,03** |
| **Any Complication %** | 30 | 29 | 33 | 0,07 |
| **ICU LOS median** | 2d | 2d | 3d | **<0,01** |
| **Hospital LOS median** | 7d | 7d | 8d | **0,01** |
| **Discharge Home %** | 76,4 | 82,4 | 75,7 | **<0,01** |

*Table 3a: Overview of the Main Study Outcomes for the whole study population (Overall) for the nonPAS group and the PAS group with calculated p-values for the significance of difference between the groups. Table modified from previous publication by Bertrand et al (1).*

| 3.b Breakdown of postoperative Surgical Complications (%) | | | | |
|---|---|---|---|---|
| | **Overall N:2034=100%** | **NonPAS 73%** | **PAS 27%** | **Difference p-value** |
| **All Surgical Complications** | 21 | 21 | 22 | 0,65 |
| **Ischemic Colitis** | 3,2 | 2,6 | 4,7 | **0,02** |
| **Bleeding *** | 68,1 | 66,8 | 71,6 | **0,04** |
| **Surgical site infections superficial** | 1,4 | 1,3 | 1,6 | 0,54 |
| **Surgical site infection deep** | 0,37 | 0,5 | 0,0 | 0,11 |
| **Surgical site infection organ space** | 1,0 | 0,9 | 1,3 | 0,42 |
| **Wound disruption** | 1,5 | 1,7 | 0,9 | 0,20 |
| **Lower extremity ischemia (requiring reintervention)** | 1,8 | 2,0 | 1,3 | 0,30 |
| **Aneurysm rupture postoperatively** | 0,5 | 0,5 | 0,5 | 0,99 |
| **Actue renal insufficiency** | 3,2 | 3,4 | 2,7 | 0,47 |

*Table 3b: Breakdown of postoperative 30day Surgical Complications reported in percentages, reported for the whole study population (Overall) for the nonPAS group and the PAS group with calculated p-values for the significance of difference between the groups. Table modified from previous publication by Bertrand et al (1). "* Postoperative bleeding was defined as any bleed requiring transfusion and was differentiated from perioperative bleeding as time of bleed .24h after surgery."(1)*

| 3.c Breakdown of postoperative Non-Surgical Complications (%) | | | | |
|---|---|---|---|---|
| | **Overall N:2034=100%** | **Non PAS 73%** | **PAS 27%** | **Difference p-value** |
| **Progressive renal insufficiency** | 2,7 | 2,5 | 3,1 | 0,45 |
| **Myocadial infarction** | 3,3 | 2,9 | 4,5 | 0,06 |
| **Stroke** | 0,8 | 0,6 | 1,3 | 0,13 |
| **Cardiac arrest with CPR** | 1,7 | 1,8 | 1,5 | 0,46 |
| **Pneumonia** | 6,1 | 6,1 | 6 | 0,96 |
| **Pulmonary Embolism** | 0,4 | 0,3 | 0,5 | 0,51 |
| **UTI** | 2,3 | 1,6 | 4,2 | **<0,01** |
| **DVT/Thrombophelbitis requiring Therapy** | 1,5 | 1,4 | 1,6 | 0,71 |
| **Sepsis** | 1,5 | 1,3 | 2,2 | 0,18 |
| **Septic Shock** | 2,8 | 2,6 | 3,5 | 0,32 |

*Table 3c: Breakdown of non-surgical 30day postoperative outcomes for the whole study population (Overall) for the nonPAS group and the PAS group with calculated p-values for the significance of difference between the groups. Table modified from previous publication by Bertrand et al (1).*

## c. Intraoperative Outcome: Operating Time

As previously reported in Table 3a there was a significant difference between operating times between the groups. While the overall study population had a median operating time recorded of 230min, the PAS group median was 237min and the nonPAS group was 227min. This 10minute difference had a p-value of p=0.03. While this is technically a statistically significant difference the actual value of a 10minute difference in surgery is debateable (as discussed in the discussion). To better display the distribution of the data and compare this between the groups a Box-plot of the operating times was created for both groups: Figure 2, previously published by Bertrand et al (1).

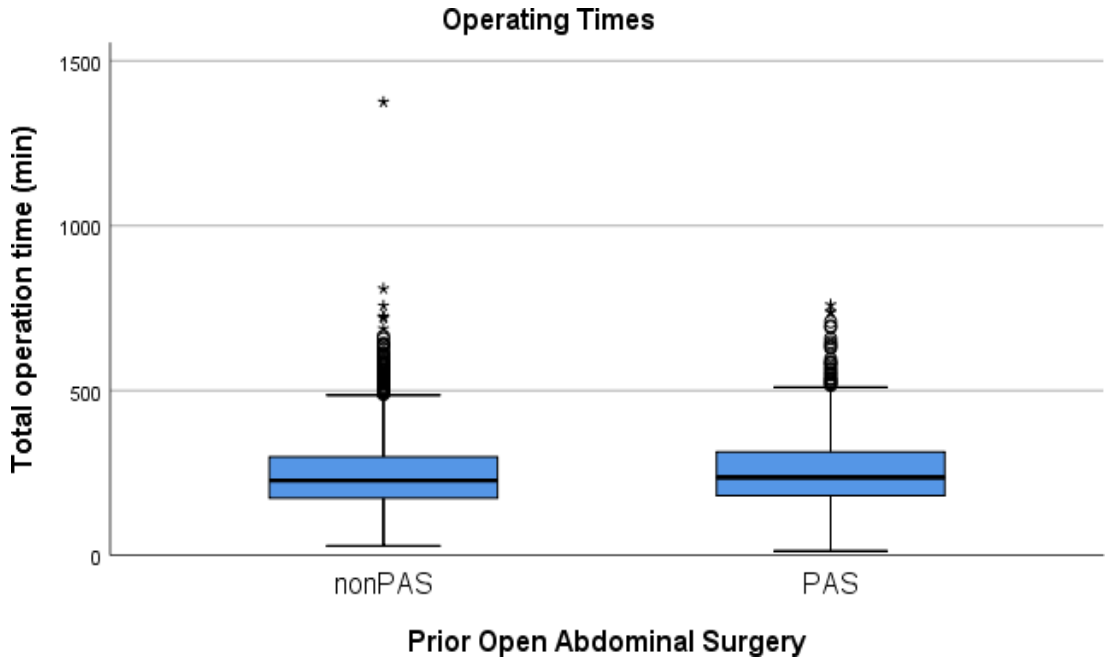


*Figure 2 "Boxplot of Operating Times comparing the nonPAS group with the PAS group" (1) previously published by Bertrand et al (1)*

As previously described in variable selection, other intraoperative variables included: surgical approach (retro or transperitoneal), proximal clamp location, renal revascularisation, visceral revascularisation, and management of inferior mesenteric artery. Of these, besides total operation time, surgical approach was the only other statistically significant difference between the groups. Retroperitoneal exposure was reported in 22.4% of the nonPAS group vs 30.3% of the PAS group p<.01. A full report of all the intraoperative results is available in Appendix 5.

## d. Length of Stay Outcomes and Discharge Destination

Patients with PAS had reportedly longer overall in hospital stays and intensive care unit stays compared to non PAS patients. Overall stay was 8days PAS vs 7days nonPAS (p=0.01) and ICU stay was 3days PAS vs 2days nonPAS (P<0.01). While the difference each time is only of one day, the size of the groups is large enough with several hundreds of patients staying longer by one day on average that the result is relevant. To portray this Figures 3 and 4 below, previously published by Bertrand et al (1), were created visualising a clear difference between the groups.

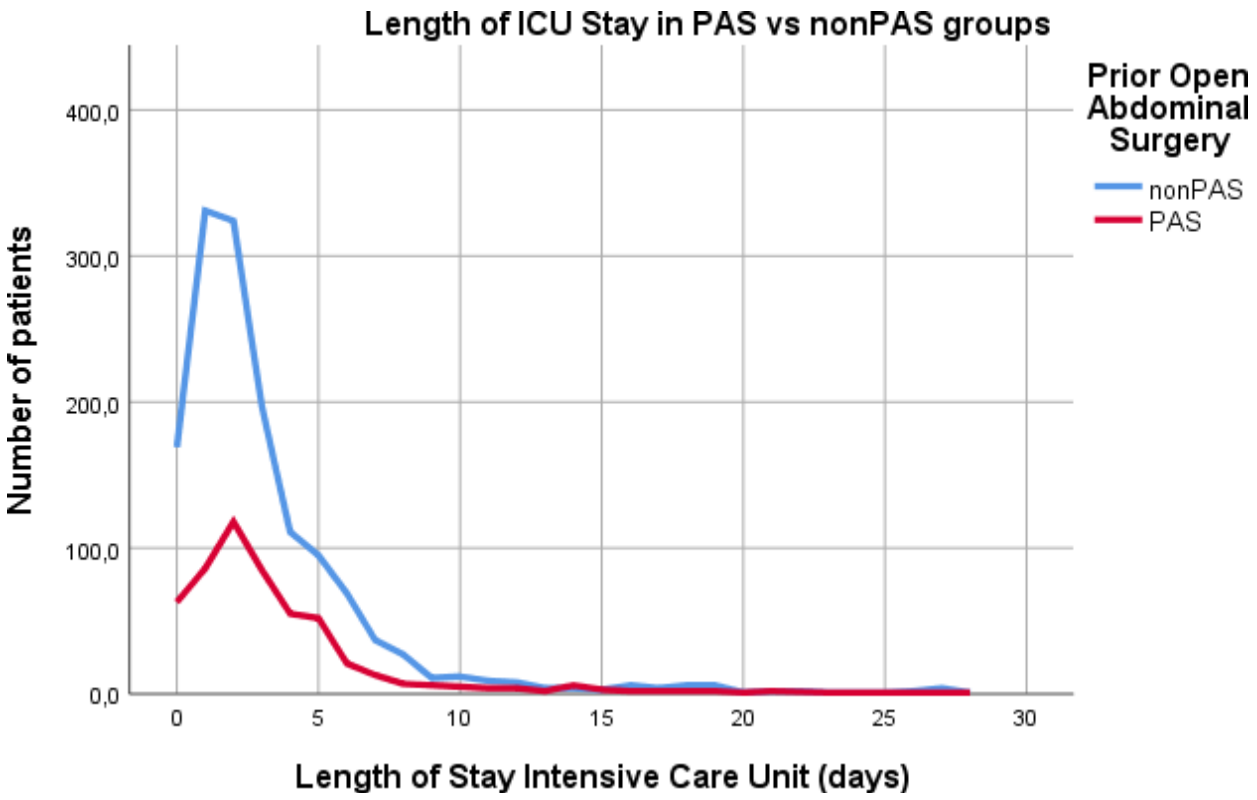


*Figure 3 "Graph presenting the length of Stay in Intensive Care (in days) for patients in the PAS group compared to the nonPAS group"(1). Graph previously published by by Bertrand et al (1).*

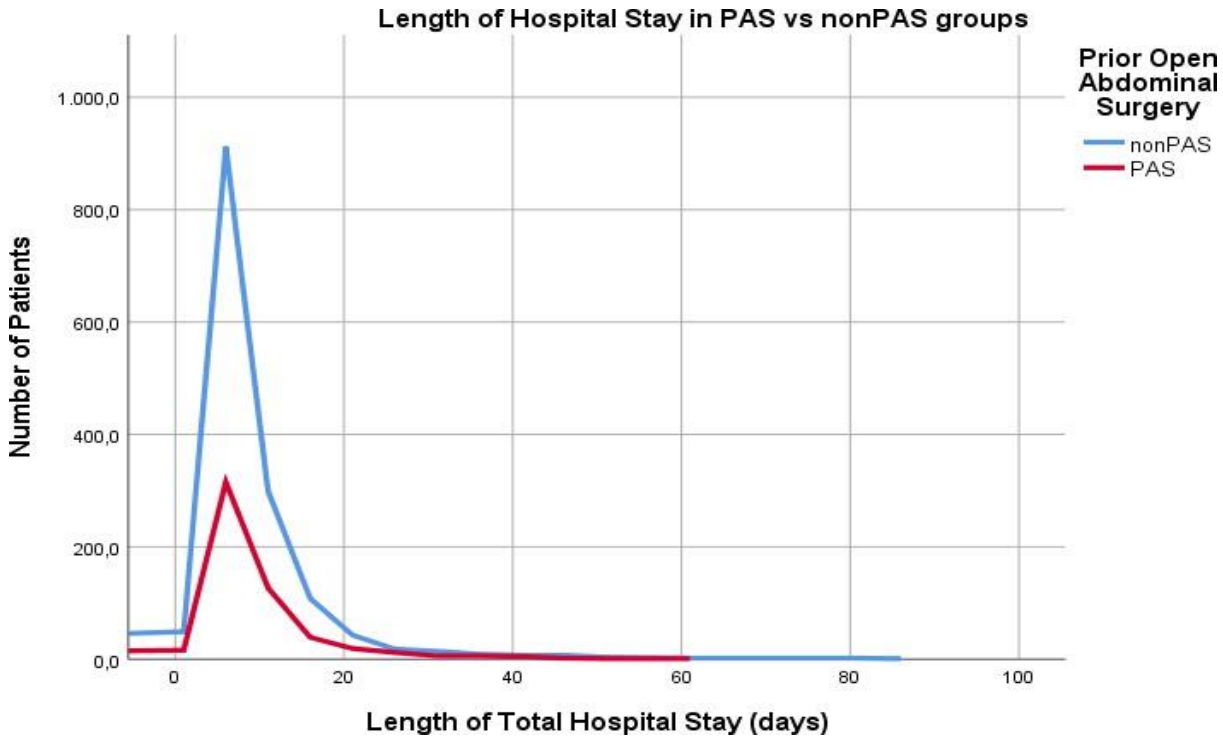


*Figure 4 "Graph presenting length of stay in hospital (in days) for patients in the PAS group compared to the nonPAS group" "(1). Graph previously published by by Bertrand et al (1).*

Finally, reporting on discharge destination allowed insight to general patient wellbeing beyond the 30day postoperative recording point. In this outcome (reported in Table 3a) the PAS group once again fared considerably worse, with only 75.7% returning straight home compared to 82.4% in the nonPAS group (p< .01).

## e. Multivariate analysis: Tables 4, 5, 6

30DAY MORTALITY:

Corroborating the findings of the univariate analysis, the multivariate analysis also showed no difference in of 30-day mortality between the groups. An Odds ratio of 0.67 is reported with 95%CI [0.38 to 1.18] and p = .16 (Table 4).

Along with demographic, comorbidity, and aneurysm parameters, each of the intraoperative variables were also included in the screening for inclusion for this multivariate analysis. Besides operating time none were statistically significantly associated with increased 30day mortality (surgical approach p=.42, clamp location p=0.62, renal revascularisation p=0.58, IMA revascularisation p=0.28). Therefore only operating time was actually included in the regression calculations.

Looking at the regression calculation there are some incidental findings for statistically significant risk factors for 30day mortality of OSR for AAA (unrelated to PAS). These included age (OR1,08 [1.04-1.12] p< .01), preoperative dialysis (OR10.3 [2.51-42.47] p< .01), disseminated cancer (OR10.8 [1.65-42.47] p = .01), proximal aneurysm extent (OR1.32 [1.06-1.65] p0.01), operating time (OR1.03 [1.01-1.05] p< .01), and history of severe COPD (OR2.96 [1.78-4.89] p< .01).

| Logistic Regression for 30day Mortality (1) | | | |
|---|---|---|---|
| | Odds Ratio | 95% Confidence Interval | p-value |
| **PAS** | **0,67** | **0,38 – 1,18** | **0,16** |
| Gender | 0,71 | 0,42 – 1,21 | 0,21 |
| Age | 1,08 | 1,04 – 1,12 | **<0,01** |
| BMI | 0,97 | 0,92 – 1,02 | 0,29 |
| ASA | 1,55 | 0,99 - 2,41 | 0,05 |
| Functional Status | 1,42 | 0,56 – 6,10 | 0,50 |
| Smoker | 0,69 | 0,40 - 1,20 | 0,19 |
| On Steroids | 1,76 | 0,68 – 4,58 | 0,25 |
| CHF | 1,85 | 0,56 - 6,10 | 0,31 |
| Severe COPD | 2,95 | 1,78 – 4,89 | **<0,01** |
| Hypertension | 1,26 | 0,62 - 2,56 | 0,52 |
| Dialysis | 10,3 | 2,51 – 42,47 | **<0,01** |
| Disseminated cancer | 10,8 | 1,65 - 42,47 | **0,01** |
| Systemic Sepsis | 0,86 | 0,38 – 1,94 | 0,72 |
| Bleeding disorders | 1,77 | 0,84 - 3,67 | 0,13 |
| Surgical indication | 1,11 | 0,94 - 1,31 | 0,24 |
| proximal extent | 1,32 | 1,06 – 1,65 | **0,01** |
| OP Time | 1,03 | 1,01 - 1,05 | **<0,01** |

*Table 4 previously published by Bertrand et al (1) showing the results of the step-forward Logisitic Regression for 30day Mortality, including Odds Ratios, 95% Confidence Intervals and p-values. Values included were any variable that in univariate analysis proved to be associated with the 30day mortality outcome with a significance of p<0.2.*

ISCHEMIC COLITIS:

On univariate analysis PAS was associated to an almost twofold higher ischemic colitis rate. A multivariate analysis was performed to verify the association and determine if PAS was an independent risk factor of ischemic colitis after OSR for AAA: Table 5 as previously published by Bertrand et al (1). However, the odds ratio of 1.65 had a 95% confidence interval of 0.96 to 2.84 with a p=0.07, narrowly missing the cutoff for statistical significance. This result shows PAS presenting tendency towards increased risk but not to the point of an independent risk factor for ischemic colitis.

As with 30day mortality, all aneurysm parameter and intraoperative variables were included in the screening for association to ischemic colitis for inclusion into the regression calculation. Distal extent into the iliacs was not associated with ischemic colitis rates (p=0.81). Visceral revascularisation (SMA or Coeliac) was very rare – especially so as supramesenteric aortic clamping was actually an exclusion criteria – and was associated with higher ischemic colitis rates (p=0.08). However as discussed previously, it was hypothesised that visceral revascularisation was on the causal pathway between previous abdominal surgery affecting ischemic colitis rates and should therefore not be corrected for in the multivariate analysis. The intraoperative IMA status was also not significantly associated to ischemic colitis.

As displayed in the regression Table 5, there were some incidental findings of other independent risk factors for ischemic colitis after OSR of AAA: a high ASA score (p< .01), a history of severe COPD (p= .02), aneurysm diameter (p = .01) and longer than median operating time (p< .01).

| Logistic Regression for Ischemic Colitis (1) | | | |
|---|---|---|---|
| | Odds Ratio | 95% Confidence Interval | p-value |
| **PAS** | **1,65** | **0,96 – 2,84** | **0,07** |
| Gender | 0,89 | 0,50 - 1,59 | 0,70 |
| ASA | 2,62 | 1,59 – 4,31 | **<0,01** |
| On Steroids | 1,59 | 0,58 - 4,31 | 0,37 |
| Severe COPD | 1,92 | 1,1 – 3,36 | 0,22 |
| Aneurysm diameter | 0,75 | 0,6 - 0,93 | 0,10 |
| Aneurysm proximal extent | 1,21 | 0,96 – 1,53 | 0,11 |
| OP Time | 1,03 | 1,01 - 1,05 | **<0.01** |

*Table 5 As previously published by Bertrand et al (1) Results of step-forward Logistic Regression for Ischemic Colitis, including Odds Ratios, 95% Confidence intervals and p-values. Variables included in the analysis were those that in univariate analysis proved to be associated with the outcome Ischemic Colitis with a significance of p<0.2.*

OPERATING TIME:

After showing significant differences in univariate analysis (PAS median 237min operating time vs nonPAS 227min p=0.03), operating time was also an independent risk factor for both postoperative mortality and ischemic colitis rates. For this reason it was deemed appropriate to perform a third multivariate analysis focussed on Operating Time alone: Table 6 as previously published by Bertrand et al (1). The resulting coefficient showed an increase of 11.8 minutes in patients with PAS, 95% CI [-0.28 -23.9] and p=0.06, once more narrowly missing the cutoff for statistical significance.

| Linear Regression for Operating Time (1) | | | |
|---|---|---|---|
| | Coefficient | 95% Confidence Interval | p-value |
| **PAS** | **11.8** | **-0.28, 23.9** | **0.06** |
| Gender | 19.6 | 7.19, 31.99 | **<0.01** |
| Age | -1.2 | -1.83, -0.58 | **<0.01** |
| BMI | 1.3 | 0.37, 2.26 | **<0.01** |
| ASA | 6.5 | -2.49, 15.55 | 0.16 |
| Functional status | 30.6 | -3.02, 64.33 | 0.07 |
| On Steroids | 15.8 | -13.61, 45.16 | 0.29 |
| COPD | 17.3 | 3.93, 30.70 | 0.01 |
| Hypertension | 8.4 | -4.60, 21.36 | 0.21 |
| Diabetes | 9.4 | -6.36, 25.07 | 0.24 |
| Preoperative Sepsis | 13.7 | -7.10, 34.55 | 0.20 |
| Bleeding disorder | 13.3 | -6.93, 33.59 | 0.20 |
| Aneurysm diameter | 2.85 | -0.90, 6.60 | 0.14 |
| Aneurysm proximal extent | 9.4 | 3.73, 15.16 | **<0.01** |
| Aneurysm distal extent | 17.7 | 10.58, 24.91 | **<0.01** |
| Surgical indication | 5.3 | 0.88, 9.81 | 0.02 |

*Table 6 As previously published Bertrand et al (1) Results of linear regression analysis for Operating Time including the Coefficient, 95%Confidence Intervals and p-values. Variables included in the analysis were those that in univariate analysis proved to be associated with the outcome of Operating Time with a significance of p<0.2.*

# f. Supplementary Analyses

## i. Exclusively Male Patients: Table 7

As reported in Table 2 the proportion of Female patients was significantly higher for PAS cases: 42% vs 23% nonPAS (p<.01). To examine a potential bias in the data from gynaecological operations counted in female patients but not in male patients additional analyses were performed using only male patients. The results showed no statistical difference in 30day mortality between PAS vs nonPAS in both univariate (p=.72) and multivariate (p=.39) analyses. Ischemic colitis was significantly higher in the PAS group on univariate analysis (p=.05) but not on multivariate analysis (p=.16). Operating time was significantly longer in the PAS group on univariate analysis (p=.01) but not on multivariate analysis (p=.15). A summary of these results is presented in Table 7 while the full results of the analyses including the results of all variables included in the regression calculations are presented in Appendix 5. Overall the results of the study were not meaningfully different when analysing the whole study population vs when studying male patients only.

| Male Patients Only: comparing PAS vs nonPAS | | |
|---|---|---|
| **Outcome** | **Univariate analysis** p-value | **Multivariate analysis** OR [95%CI] p-value |
| 30d Mortality | p=.72 | OR 0.71 [0.33,1.43] p=0.39 |
| Ischemic Colitis | p=.05 | OR 1.64 [0.83,3.23] p=0.16 |
| OP Time | p=.01 | Coeff 11.4 [-4.13,26.95] p=0.15 |

*Table 7: Summary of the Main results recalculated using Male Patients Only. P-values shown are the calculated significance level of the difference between PAS and nonPAS groups. Full results including statistical details of regression calculations and choice of statistical test for p calculations are reported more extensively in Appendix 5*

### ii. Trends over Time: Table 8

Changes through time in this data set are reported in Table 8. The year with proportionately the least number of PAS patients was the starting year of recording 2011: 15.1%. The highest recorded proportion of PAS was in 2015: 35.1%. The final year 2017 reported 26% PAS cases. Overall there was a general increasing trend in proportion of PAS.

Postoperative 30day mortality of OSR increased over time, the starting mortality in 2011 was 3.8%. The lowest mortality was recorded in 2012: 3% and the highest mortality was reported in 2017: 5.4%. There was a clear increasing trend in overall mortality.

Ischemic colitis did not show any discernible trend over time. All years reported between 2% and 6%. The lowest rate of ischemic colitis was reported in 2013: 2.2% and the highest rate of ischemic colitis was reported in 2015: 5.9%.

Overall 74.7% of patients received a transperitoneal OSR while 24.2% were operated using a retroperitoneal approach. There was no discernible trend over time.

The discharge destinations did vary somewhat between the years. Maximum proportion of discharge home was achieved in the last year of recording: 80.9%. The minimum proportion was in 2011: 72.6%. All other years reported discharge home between 75%(2015) and 78%(2012).

Additional calculations were made to follow trends in association between PAS and outcomes over time. However to avoid significance fishing these results are not included in this main manuscript but rather reported in full in Appendix 6. Overall these results did show any particular unexpected outliers in the data.

| Trends Over Time | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Variable** | | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **Total** |
| | **N**:caseload | **186** | **400** | **272** | **287** | **256** | **298** | **335** | **2034** |
| **PAS** | No(%) | 84,9 | 78,3 | 70,2 | 69 | 64,8 | 70,8 | 73,7 | 73 |
| | Yes(%) | 15,1 | 21,8 | 29,8 | 31 | 35,2 | 29,2 | 26,3 | 27 |
| **30Dmortality** | deceased(%) | 3,8 | 3 | 4 | 5,2 | 3,9 | 3,4 | 5,4 | 4,1 |
| **Ischemic Colitis** | Yes(%) | 3,8 | 3 | 2,2 | 2,4 | 5,9 | 3 | 2,7 | 3,2 |
| **Approach** | Retro(%) | 28 | 24,3 | 20,2 | 23,7 | 30,9 | 20,1 | 24,5 | 24,2 |
| | Trans | 71,5 | 75 | 78,3 | 75,6 | 68,8 | 77,9 | 74 | 74,7 |
| **Discharge destination** | Home/unskilled facility (%) | 72,6 | 78 | 76,5 | 76,3 | 75 | 77,5 | 80,9 | 77,1 |
| | skilled facility | 23,1 | 19 | 19,5 | 17,8 | 20,3 | 18,8 | 14 | 18,6 |

*Table 8 percentages of patients with previous abdominal surgery, mortality, ischemic colitis, surgical approach, and discharge destination reported separately between the recorded years*

# 4. DISCUSSION

## a. Context

Despite the modern rise of EVAR, there still remains an important place for OSR of AAA. Previous studies (7-10) have shown OSR still has favourable long-term results for patients that are younger and treated electively. In the USA for example, over 5000 'young' patients (50 to 65) receive elective AAA treatment every year (45). These patients have the most QALYs to gain from appropriate treatment allocation. Indeed predicting which patients will have better outcomes with OSR challenges modern vascular surgeons. Tailored decision making calls for evidence based medicine, however this evidence is lacking for some perceived surgical risk factors. Previous risk factor models have focussed on cardiovascular and renal comorbidities to aid decision making (23-25). However landmark papers (11) have allowed surgeons to self-define patients who are 'unfit' for surgery. One reason a patient may be categorised as 'unfit' is previous abdominal surgery, especially multiple or extensive surgeries. Adhesions that may cause surgery to be more extensive can, however, also present after one surgical abdominal entry (32). As shown in Table 8 of the results, the proportion of patients undergoing OSR of AAA that have PAS is overall at 27%, and this proportion has had the overall tendency to increase between the studied timeframe of 2011 to 2017. Surgeons are thus, increasingly faced with patients eligible for OSR with prior abdominal surgery.

This research contributes evidence to the question of what influence previous open abdominal surgery has to the main outcomes of elective open surgical repair for abdominal aortic aneurysms. After looking at comparability of the groups, the following discussion goes on to interpret the study's results. Because the results are somewhat contradictory, a careful examination of the findings and their context is necessary for a meaningful understanding of the information at hand.

## b. Comparability of the Groups

As shown in Table 2 of the results the main differences between the PAS and nonPAS groups were gender, age and ASA score.

In terms of gender, the PAS group had more women (42%) compared to the nonPAS group (23%), this difference was statistically significant (p<.01). One plausible explanation for this difference was gynaecological surgery such as C-sections or open hysterectomies. These surgeries are in the abdominal cavity and 'count' as PAS for the NSQIP database. From previous studies (46,47) there is evidence that female patients undergoing AAA repair, be it open or endovascular, have consistently worse long and short term results (46, 47). In order to investigate this further a supplementary analysis was performed (Table 7 and Appendix 6). None of the main study findings were any different when repeating the calculations using men only.

The PAS group had a median age 2 years higher than the nonPAS group (p<.01). This is understandable as older patients are likely to have undergone more previous procedures simply due to longer time in care. The difference of 2 years, while statistically significant, is interpreted as a relatively small absolute value.

The proportion of patients scored > ASA III was 42% in the PAS group vs 36% nonPAS, p = .04. This result is likely caused by the higher age of the patients. However this difference is put somewhat into perspective considering the functional status grading of the groups was comparable: only 1% difference in functionallz independent patients (97% PAS vs. 98% nonPAS, with p = .08).

Nevertheless, each of these factors (gender, age, and ASA>III) could, potentially "negatively bias the results, and exaggerate negative effects of PAS" (1). As argued in the published study with this data(1) "overall results actually show no significant difference for main outcomes and multivariate analysis corrected for each factor, (therefore) we argue that these bias factors were of no great consequence to the interpretation of the main results".

## c. Interpretation of the Main Study Findings

POSTOPERATIVE 30DAY MORTALITY

Both univariate and multivariate analysis show that prior abdominal surgery is not associated to increased 30day postoperative mortality. Multivariate analysis showed OR 0.67 95%CI [0.38 – 1.18] p = .16. This result is repeatedly reported, not only the main findings, but also in recalculations using male patients only and in individual calculations involving each year separately (Appendix 6 & 7). With such a large study population (N=2034) over 7 years, this is interpreted as conclusive evidence to reject the hypothesis that PAS is associated with increased 30day mortality after OSR for AAA. Having said this, further evidence (discussed below) does show other overall negative trends for the PAS group. In hindsight, it is possible that this primary outcome was perhaps not sensitive enough to capture a more subtle negative impact that PAS may still have on OSR.

ISCHEMIC COLITIS

Indeed, “indicative of a more traumatic surgical preparation in the PAS group” (1) there was an significantly higher ischemic colitis rate after PAS: (“PAS 4.7% vs nonPAS 2.6% p=0.02” (1)). However, this result was not supported in the multivariate analysis: (OR 1.65 95%CI [0.96,2.84] p = .07). On the other hand, each of the absolute values comparing PAS and nonPAS groups, show worse outcomes for the PAS group. This is true not only in the main findings (Tables 3 and 4), but also repeatedly in the supplementary recalculations using male patients only and results by year (Tables 7 and 8). This is interpreted as evidence of a negative trend for ischemic colitis as an outcome after OSR of AAA in PAS patients, but no conclusive association was captured in this research. While continued analyses in this dataset would risk significance fishing, further research in this field is warranted and likely necessary.

OPERATION TIME

Operating times, were longer in the PAS group “median of 237min PAS vs 227nonPAS p = .03” (1). While this difference of ten minutes may not be that long, only one previous abdominal surgery was required to categorise as ‘PAS’. Considering the

large body of data, this difference may well be indicative of time consuming adhesiolysis or accidental injuries due to intraabdominal scars. Other results that would support this interpretation include increased rates of postoperative bleeding (PAS 71.6% vs nonPAS 66.8%, p= .04).

Again, as with ischemic colitis, this result – while repeatedly shown in supplement calculations (Tables 7 and 8)– did not hold up to multivariate analysis (Table 5): (OR 1.65 95%CI [0.96 – 2.84] p = .07). The absolute differences measured between the groups was also not very long compared to the overall length of the procedure, a difference of 10 minutes for a procedure of almost 4 hours in median measurements overall. As such this data is actually interpreted as the strongest evidence in the study against the hypothesis. This is evidence that PAS should perhaps not be considered as an independent risk factor of OSR for AAA.

## d. Interpretation of other Secondary Outcomes

Having said this, some of the remaining secondary outcomes continue to provide evidence that a more subtle difference exists in the outcomes of OSR after PAS. Postoperative bleeding for example, as mentioned before was 4.8% higher ("PAS 71.6% vs nonPAS 66.8%, p= .04" (1)). Overall complication rates were 4% higher ("PAS 33% vs nonPAS 29% p = 0.07" (1)). Lengths of stay were consistently longer by one day for both overall and ICU results. Average length of stay overall was 8days PAS vs 7days nonPAS (p = .01). And for stay in Intensive Care ICU, the average length was 3days PAS vs 2days nonPAS (p<.01). These results are not only indicative of an increased burden for patients due to longer admission times but also come with higher costs for the PAS group overall. In terms of patient burden, the discharge destinations also point towards worse outcomes for PAS patients, with 75.7% returning home compared to 82.4% in the PAS group (p<.01). As previously discussed (1) the differences in discharge destination could "suggest the subtle differences between the groups may actually show on results beyond the 30day cut-off in which the NSQIP database collects data" (1).

These more subtle differences and trends are a testament to the need for more targeted research in this domain. However, looking at this body of research as a whole, the reported differences are not interpreted as sufficient to stop the rejection of

the null hypothesis. The overall evidence still suggests that PAS is not an independent risk factor for OSR of AAA.

## e. Interpretation of Supplementary Analyses

- INCREASING PAS OVER TIME

In the initial conception of the study it was hypothesized that dealing with prior abdominal surgery was likely to be an increasing problem for physicians facing the choice OSR vs EVAR. To test this and better contextualise this research supplementary analysis included reporting on the overall trends in time for the proportion of patients having undergone PAS. The proportion of patients with PAS did indeed increase over time (Table 8), from 15.1% in 2011 to more than double 35.2% in 2015 and finally 26.3% in 2017. This may be explained by three global trends. Firstly the concerted global effort to improve access to healthcare and surgical care in particular (44). Secondly the continuous improvement of general medicine screening programs and medical imaging. And thirdly the continued aging of the global population.

## f. Incidental Findings

- COPD: PREDICTIVE FACTOR FOR MORTALITY

When looking at the multivariate analysis for 30day mortality, COPD is a notable predictor for death in this data. Overall 19% of patients had COPD, and this was associated with an odds ratio of 2.95 of 30day postoperative death from any cause (95%CI[1.78 – 4.89] p< .01). While this is not surprising it is worth mentioning because COPD is not included in the “Vascular Quality Initiative Mortality risk score” (22). While it is included in the Glasgow Aneurysm score (23) and modified Leiden score (24), it is underscored compared to CHF. In this analysis CHF and AHT as well as Dialysis were associated to 30dMortality of OSR to a far smaller degree, affecting a much smaller proportion of the OSR AAA population. This may indicate that future research of the role of COPD in risk models and the weight it is given, is warranted.

- SURGICAL APPROACH

As previously mentioned, the 2018 SVS guidelines (22) advise surgeons to choose a retroperitoneal surgical approach when a hostile abdomen is anticipated. The fact

that the recommendation level is strong (level 1) despite low quality of evidence (C), shows that more evidence is needed in this space. The surgical approach (retroperitoneal vs transperitoneal) variable was available for most patients (missing data in 75 patients). Unsurprisingly, the PAS group had more retroperitoneal approaches than the non PAS group (31% vs 22,5% respectively with p<0,01). This can be understood as verification that surgeons do in fact follow guideline advice to opt for retroperitoneal approach when anticipating a possible hostile abdomen.

In the statistical process of screening for variables that were independently associated with the outcomes that underwent multivariable analysis, surgical approach was also analysed. As none of these associations were statistically significant above the present threshold of p<.2, surgical approach was excluded from further multivariate regression calculations. As discussed in the previous publication (1), “we propose two interpretations of these results: one is there really is no difference in these main outcomes whether approach is retro- or transperitoneal. Secondly is that patients are already being selected appropriately for retroperitoneal approach, potentially masking the dangers of transperitoneal OSR after PAS.”

## g. Study Limitations

Due to the retrospective design of the study, there is a risk of sampling bias in this OSR AAA study population. Patients included in the study would have already been selected by surgeons as appropriate candidates for OSR. It is possible, even likely, that patients who had previously undergone extensive or multiple PAS, were not offered OSR to begin with. For this reason there is some risk of a type II error, falsely declaring no association between PAS and results of OSR, when in fact the effect had been masked by biased patient selection. However, a prospective study in which patients are randomly assigned to OSR would be unethical. Also, patients who are very obviously unfit for OSR are not the cases in which tailored decision making is difficult. Therefore, considering the clinical relevance of this study population, it is arguably still relevant to perform and report on this retrospective data.

NSQIP data is always limited to a time frame of 30days, as previously discussed some of the results, particularly the destination of discharge, point to a clear disadvantage for the PAS group beyond this 30day cutoff. Additionally a more

extensive surgery including adhesiolysis may also cause complications such as bowel obstruction in the months and years postoperatively. These differences are not captured in this data limited to 30days. On the other hand, this short and defined follow up period allows widespread participation from hospitals around the world. This contributes to the large case numbers (N2034) that this research has the privilege to analyse. Also the high number of recorded variables allows for extensive multivariate testing, a statistical step that has proven very important in the analysis of these results, ultimately overturning univariate findings.

As previously established, this research is based on NSQIP Data on OSR of AAA collected from 2011 to 2017, considering the delay in publication to 2024 there is a limitation in the applicability of the findings in today's clinical setting. The reason for this selected time frame (as explained in the methods) is the availability of the data at the date of conception of the study design (2020). However, as techniques of OSR have not significantly changed in the past 6 years, and the PAS recorded in the history of the patients may well be of a much older date than 6years, we would argue that the selected time frame of 2011-2017 is unlikely to skew or bias results and remains adequate for applying new knowledge to today's setting.

Using the NSQIP database for this research allowed a very broad catchment of previous abdominal surgeries to provide a first glance into this topic. That is to say, any surgery entering the intra-abdominal space previous to AAA repair would count as a PAS, regardless of the number of surgeries or extent of it. While this allows for a high inclusion factor it is also the study's most important limitation. What counts as PAS is likely very heterogenous, and the fact that this data is unavailable, limits the level to which this study can really gain insight into this clinical problem. However, in the context of having a limited body of existing evidence of the effect of previous abdominal surgery on the outcomes of OSR, the results of the study do have a place. Specifically when seeing evidence of surgeon-led patient selection within large impactful studies such as EVAR 1 & 2 that continue to be the basis for current day decision making, we feel there is a need to shed even this limited light on the evidence that is available.

# 5. CONCLUSION

EVAR has developed into the internationally favoured treatment mode for AAA, however some patients are still better treated by traditional open repair (OSR). The increasingly difficult burden for contemporary vascular surgeons is correctly identifying which patients should be selected for OSR. One perceived risk for OSR of AAA is previous open abdominal surgery (PAS). This study shows that between 2011 and 2017 the proportion of patients that had previously undergone open abdominal surgery gradually increased, overall almost one third of cases had PAS.

PAS was not associated to a worsening of the primary outcome: all cause 30day mortality. Considering the size of the study and the time frame collected, we conclude that this is strong evidence that there is no association between PAS and all cause 30day mortality.

Other outcomes were more ambiguous. There is a consistent thread in the data showing that the PAS group does fare worse. Univariate analysis did show statistically significant differences in ischemic colitis and operating times, multivariate analysis showed worse results for PAS that narrowly missed statistical significance. Other univariate analysis results also showed worse outcomes for the PAS group including higher bleeding rates, longer hospital stays, less discharge to home. However, these were not subject to further testing on multivariate analysis and thus should be approached with some caution.

While this study was not able to conclusively objectify clear negative effects cause by PAS in and of its own, the overall negative trends do suggest that it is plausible that subgroups with extensive and/or multiple previous surgeries may indeed be associated with worse outcomes. However, we conclude that these findings, as they stand, would not warrant exclusion of patients from consideration for OSR based on past medical history of PAS in and of its own.

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# APPENDIX 1. Ethics Commission Statement

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

ETHIKKOMMISSION BEI DER LMU MÜNCHEN

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01.10.2020/Hb/mbg

Projekt Nr: **KB 20/008** (bitte bei Schriftwechsel angeben)

**Keine Beratungspflicht**

Projekt: Einfluss von vorheriger Abdominalchirurgie auf die Ergebnisse von offenen Reparaturen abdomineller Aortenaneurysmen

Antragsteller: Doktorand: Laurence Bertrand
Betreuer: Professor Dr. Tsilimparis, Abteilung für Gefäßchirurgie, Standort Großhadern, Klinikum der Universität München, Marchioninistr. 15 81377 München

Sehr geehrter Herr Prof. Tsilimparis, sehr geehrter Herr Bertrand,

haben Sie besten Dank für Ihr Schreiben (e-mail) vom 30.09.2020, mit dem Sie um eine Unbedenklichkeitserklärung für das o. g. Projekt bitten.

Die Ethikkommission der LMU bestätigt, dass für das o.g. Forschungsvorhaben keine Beratungspflicht durch die Ethikkommission besteht.

Vorsorglich möchte ich darauf hinweisen, dass auch bei einer positiven Beurteilung Ihres Vorhabens die Verantwortung für die Durchführung des Projektes uneingeschränkt bei Ihnen und Ihren Mitarbeitern verbleibt.

Für Ihre Untersuchungen wünsche ich Ihnen viel Erfolg.

Mit freundlichen Grüßen

Prof. Dr. W. Eisenmenger
Vorsitzender der Ethikkommission

# APPENDIX 2. Complete List of NSQIP Variable 2017

| Advisement: When a change in definitions across PUF years is noted, users should attend to this if they merge files. It is suggested that they evaluate variable categories across years and combine them in a manner appropriate to their research objectives. | | | | | | |
|---|---|---|---|---|---|---|
| Position # | Variable Name | Data Type | Variable Label | Search Term in Chapter 4<br>Notes: "Variable Name:" needs to be included in Search Term;<br>"Variables not included in Chap 4 | Variable Options at Entry | Comments |
| 1 | PUFYEAR | Char | Year of PUF | "Year of PUF | | |
| 2 | CaseID | Num | Case Identification Number | Variable Name:Identification Number (IDN) | | NULL = No Response |
| 3 | SEX | Char | Gender | Variable Name:Gender | Male; Female | NULL = No Response |
| 4 | RACE_NEW | Char | New Race | Variable Name:Race | American Indian or Alaska Native<br>Asian<br>Black or African American<br>Native Hawaiian or Pacific Islander<br>Unknown/Not Reported<br>White | NULL = No Response |
| 5 | ETHNICITY_HISPANIC | Char | Ethnicity Hispanic | Variable Name:Hispanic Ethnicity | Yes; No; Unknown | NULL = No Response |
| 6 | PRNCPTX | Char | Principal operative procedure CPT code description | Variable Name:Principal operative procedure CPT code description | | |
| 7 | CPT | Char | CPT | Variable Name:CPT® (Current Procedural Terminology) Code | | |
| 8 | WORKRVU | Num | Work Relative Value Unit | "Work Relative Value Unit | | -99 = No Response |
| 9 | INOUT | Char | Inpatient/outpatient | Variable Name:In/Out-Patient Status | Outpatient; Inpatient | NULL = No Response |
| 10 | TRANST | Char | Transfer status | Variable Name:Origin Status | From acute care hospital inpatient<br>Not transferred (admitted from home)<br>Nursing home - Chronic care - Intermediate care<br>Outside emergency department<br>Transfer from other<br>Unknown | NULL = No Response |
| 11 | Age | Char | Age of patient with patients over 89 coded as 90+ | Variable Name:Date of Birth | | -99 = No Response |
| 12 | AdmYR | Num | Year of Admission | Variable Name:Hospital Admission Date | | -99 = No Response |
| 13 | OperYR | Num | Year of Operation | Variable Name:Operation Date | | -99 = No Response |
| 14 | DISCHDEST | Char | Discharge Destination | Variable Name:Hospital Discharge Destination | Skilled Care, Not Home<br>Unskilled Facility Not Home<br>Facility Which was Home<br>Home<br>Separate Acute Care<br>Rehab<br>Expired<br>Against Medical Advice (AMA)<br>Multi - level Senior Community<br>Hospice<br>Unknown | NULL = No Response |
| 15 | ANESTHES | Char | Principal anesthesia technique | Variable Name:Principal Anesthesia Technique | Epidural<br>General<br>Local<br>Monitored Anesthesia care (MAC) / IV Sedation<br>None<br>Other<br>Regional<br>Spinal<br>Unknown | NULL = No Response |
| 16 | SURGSPEC | Char | Surgical Specialty | Variable Name:Surgical Specialty | Cardiac Surgery<br>General Surgery<br>Gynecology<br>Neurosurgery<br>Orthopedics<br>Otolaryngology (ENT)<br>Plastics<br>Thoracic<br>Urology<br>Vascular | |
| 17 | ELECTSURG | Char | Elective Surgery | Variable Name:Elective Surgery; Patient Coming From Home | Interventional Radiologist<br>Yes; No; Unknown | NULL = No Response |
| 18 | HEIGHT | Num | Height in inches | Variable Name:Height | | -99=No Response<br>Units converted to inches |
| 19 | WEIGHT | Num | Weight in lbs | Variable Name:weight | | -99=No Response<br>Units converted to lbs |
| 20 | DIABETES | Char | Diabetes mellitus with oral agents or insulin | Variable Name:Diabetes Mellitus Requiring Therapy with Non-Insulin Agents or Insulin | INSULIN; NO; NON-INSULIN | NULL = No Response |
| 21 | SMOKE | Char | Current smoker within one year | Variable Name:Current Smoker within One Year | Yes; No | NULL = No Response |
| 22 | DYSPNEA | Char | Dyspnea | Variable Name:Dyspnea | AT REST; MODERATE EXERTION; No | NULL = No Response |
| 23 | FNSTATUS2 | Char | Functional health status Prior to Surgery | Variable Name:Functional Health Status | Independent; Partially Dependent; Totally Dependent; Unknown | NULL = No Response |
| 24 | VENTILAT | Char | Ventilator dependent | Variable Name:Ventilator Dependent | Yes; No | NULL = No Response |
| 25 | HXCOPD | Char | History of severe COPD | Variable Name:COPD (Severe) | Yes; No | NULL = No Response |

| Position # | Variable Name | Data Type | Variable Label | Search Term in Chapter 4 Notes: *Variable Name* needs to be included in Search Term; *Variables not included in Chap 4 | Variable Options at Entry | Comments |
|---|---|---|---|---|---|---|
| 28 | ASCITES | Char | Ascites | Variable Name:Ascites within 30 Days Prior to Surgery | Yes; No | NULL=No Response |
| 27 | HXCHF | Char | Congestive heart failure (CHF) in 30 days before surgery | Variable Name:Congestive Heart Failure within 30 Days Prior to Surgery | Yes; No | NULL = No Response |
| 28 | HYPERMED | Char | Hypertension requiring medication | Variable Name:Hypertension Requiring Medication | Yes; No | NULL = No Response |
| 29 | RENAFAIL | Char | Acute renal failure (pre-op) | Variable Name:Acute Renal Failure | Yes; No | NULL = No Response |
| 30 | DIALYSIS | Char | Currently on dialysis (pre-op) | Variable Name:Currently Requiring or On Dialysis | Yes; No | NULL = No Response |
| 31 | DISCANCR | Char | Disseminated cancer | Variable Name:Disseminated cancer | Yes; No | NULL = No Response |
| 32 | WNDINF | Char | Open wound/wound infection | Variable Name:Open Wound (with or without Infection) | Yes; No | NULL = No Response |
| 33 | STEROID | Char | Steroid use for chronic condition | Variable Name:Steroid/Immunosuppressant Use for a Chronic Condition | Yes; No | NULL = No Response |
| 34 | WTLOSS | Char | >10% loss body weight in last 6 months | Variable Name:> 10% Loss of Body Weight in the 6 Months Prior to Surgery | Yes; No | NULL = No Response |
| 35 | BLEEDDIS | Char | Bleeding disorders | Variable Name:Bleeding disorders | Yes; No | NULL = No Response |
| 36 | TRANSFUS | Char | Preop Transfusion of >= 1 unit of whole/packed RBCs in 72 hours prior to surgery | Variable Name:Preop Transfusions (RBC within 72 Hours Prior to Surgery Start Time) | Yes; No | NULL = No Response |
| 37 | PRSEPIS | Char | Systemic Sepsis | Variable Name:Sepsis within 48 Hours Prior to Surgery | SIRS; Sepsis; Septic Shock; None | NULL=No Response |
| 38 | DPRNA | Num | Days from Na Preoperative Labs to Operation | *Days from Na Preoperative Labs to Operation | | -99 = Lab value not obtained or No Response |
| 39 | DPRBUN | Num | Days from BUN Preoperative Labs to Operation | *Days from BUN Preoperative Labs to Operation | | -99 = Lab value not obtained or No Response |
| 40 | DPRCREAT | Num | Days from Creatinine Preoperative Labs to Operation | *Days from Creatinine Preoperative Labs to Operation | | -99 = Lab value not obtained or No Response |
| 41 | DPRALBUM | Num | Days from Albumin Preoperative Labs to Operation | *Days from Albumin Preoperative Labs to Operation | | -99 = Lab value not obtained or No Response |
| 42 | DPRBILI | Num | Days from Bilirubin Preoperative Labs to Operation | *Days from Bilirubin Preoperative Labs to Operation | | -99 = Lab value not obtained or No Response |
| 43 | DPRSGOT | Num | Days from SGOT Preoperative Labs to Operation | *Days from SGOT Preoperative Labs to Operation | | -99 = Lab value not obtained or No Response |
| 44 | DPRALKPH | Num | Days from ALKPHOS Preoperative Labs to Operation | *Days from ALKPHOS Preoperative Labs to Operation | | -99 = Lab value not obtained or No Response |
| 45 | DPRWBC | Num | Days from WBC Preoperative Labs to Operation | *Days from WBC Preoperative Labs to Operation | | -99 = Lab value not obtained or No Response |
| 46 | DPRHCT | Num | Days from HCT Preoperative Labs to Operation | *Days from HCT Preoperative Labs to Operation | | -99 = Lab value not obtained or No Response |
| 47 | DPRPLATE | Num | Days from PlateCount Preoperative Labs to Operation | *Days from PlateCount Preoperative Labs to Operation | | -99 = Lab value not obtained or No Response |
| 48 | DPRPTT | Num | Days from PTT Preoperative Labs to Operation | *Days from PTT Preoperative Labs to Operation | | -99 = Lab value not obtained or No Response |
| 49 | DPRPT | Num | Days from PT Preoperative Labs to Operation | *Days from PT Preoperative Labs to Operation | | -99 = Lab value not obtained or No Response |
| 50 | DPRINR | Num | Days from INR Preoperative Labs to Operation | *Days from INR Preoperative Labs to Operation | | -99 = Lab value not obtained or No Response |
| 51 | PRSODM | Num | Pre-operative serum sodium | Variable Name:Preoperative Lab Value Information | | -99 = Lab value not obtained or No Response |
| 52 | PRBUN | Num | Pre-operative BUN | Variable Name:Preoperative Lab Value Information | | -99 = Lab value not obtained or No Response |
| 53 | PRCREAT | Num | Pre-operative serum creatinine | Variable Name:Preoperative Lab Value Information | | -99 = Lab value not obtained or No Response |
| 54 | PRALBUM | Num | Pre-operative serum albumin | Variable Name:Preoperative Lab Value Information | | -99 = Lab value not obtained or No Response |
| 55 | PRBILI | Num | Pre-operative total bilirubin | Variable Name:Preoperative Lab Value Information | | -99 = Lab value not obtained or No Response |
| 56 | PRSGOT | Num | Pre-operative SGOT | Variable Name:Preoperative Lab Value Information | | -99 = Lab value not obtained or No Response |
| 57 | PRALKPH | Num | Pre-operative alkaline phosphatase | Variable Name:Preoperative Lab Value Information | | -99 = Lab value not obtained or No Response |
| 58 | PRWBC | Num | Pre-operative WBC | Variable Name:Preoperative Lab Value Information | | -99 = Lab value not obtained or No Response |
| 59 | PRHCT | Num | Pre-operative hematocrit | Variable Name:Preoperative Lab Value Information | | -99 = Lab value not obtained or No Response |
| 60 | PRPLATE | Num | Pre-operative platelet count | Variable Name:Preoperative Lab Value Information | | -99 = Lab value not obtained or No Response |
| 61 | PRPTT | Num | Pre-operative PTT | Variable Name:Preoperative Lab Value Information | | -99 = Lab value not obtained or No Response |
| 62 | PRINR | Num | Pre-operative International Normalized Ratio (INR) of PT values | Variable Name:Preoperative Lab Value Information | | -99 = Lab value not obtained or No Response |
| 63 | PRPT | Num | Pre-operative PT | Variable Name:Preoperative Lab Value Information | | -99 = Lab value not obtained or No Response |

| Position # | Variable Name | Data Type | Variable Label | Search Term in Chapter 4<br>Notes: 'Variable Name:' needs to be included in Search Term;<br>*Variables not included in Chap 4 | Variable Options at Entry | Comments |
|---|---|---|---|---|---|---|
| 64 | OTHERPROC1 | Char | Other Procedure 1 | Variable Name:Other Procedure | | NULL = No Procedure |
| 65 | OTHERCPT1 | Char | Other CPT Code 1 | Variable Name:Other Procedure | | NULL = No Procedure |
| 66 | OTHERWRVU1 | Num | Other Work Relative Value Unit 1 | *Other Work Relative Value Unit 1 | | -99 = No Procedure/No Response |
| 67 | OTHERPROC2 | Char | Variable Name:Other Procedure 2 | Variable Name:Other Procedure | | NULL = No Procedure |
| 68 | OTHERCPT2 | Char | Other CPT Code 2 | Variable Name:Other Procedure | | NULL = No Procedure |
| 69 | OTHERWRVU2 | Num | Other Work Relative Value Unit 2 | *Other Work Relative Value Unit 2 | | -99 = No Procedure/No Response |
| 70 | OTHERPROC3 | Char | Variable Name:Other Procedure 3 | Variable Name:Other Procedure | | NULL = No Procedure |
| 71 | OTHERCPT3 | Char | Other CPT Code 3 | Variable Name:Other Procedure | | NULL = No Procedure |
| 72 | OTHERWRVU3 | Num | Other Work Relative Value Unit 3 | *Other Work Relative Value Unit 3 | | -99 = No Procedure/No Response |
| 73 | OTHERPROC4 | Char | Variable Name:Other Procedure 4 | Variable Name:Other Procedure | | NULL = No Procedure |
| 74 | OTHERCPT4 | Char | Other CPT Code 4 | Variable Name:Other Procedure | | NULL = No Procedure |
| 75 | OTHERWRVU4 | Num | Other Work Relative Value Unit 4 | *Other Work Relative Value Unit 4 | | -99 = No Procedure/No Response |
| 76 | OTHERPROC5 | Char | Variable Name:Other Procedure 5 | Variable Name:Other Procedure | | NULL = No Procedure |
| 77 | OTHERCPT5 | Char | Other CPT Code 5 | Variable Name:Other Procedure | | NULL = No Procedure |
| 78 | OTHERWRVU5 | Num | Other Work Relative Value Unit 5 | *Other Work Relative Value Unit 5 | | -99 = No Procedure/No Response |
| 79 | OTHERPROC6 | Char | Variable Name:Other Procedure 6 | Variable Name:Other Procedure | | NULL = No Procedure |
| 80 | OTHERCPT6 | Char | Other CPT Code 6 | Variable Name:Other Procedure | | NULL = No Procedure |
| 81 | OTHERWRVU6 | Num | Other Work Relative Value Unit 6 | *Other Work Relative Value Unit 6 | | -99 = No Procedure/No Response |
| 82 | OTHERPROC7 | Char | Variable Name:Other Procedure 7 | Variable Name:Other Procedure | | NULL = No Procedure |
| 83 | OTHERCPT7 | Char | Other Variable Name:Other Procedure 7 | Variable Name:Other Procedure | | NULL = No Procedure |
| 84 | OTHERWRVU7 | Num | Other Work Relative Value Unit 7 | *Other Work Relative Value Unit 7 | | -99 = No Procedure/No Response |
| 85 | OTHERPROC8 | Char | Variable Name:Other Procedure 8 | Variable Name:Other Procedure | | NULL = No Procedure |
| 86 | OTHERCPT8 | Char | Other Variable Name:Other Procedure 8 | Variable Name:Other Procedure | | NULL = No Procedure |
| 87 | OTHERWRVU8 | Num | Other Work Relative Value Unit 8 | *Other Work Relative Value Unit 8 | | -99 = No Procedure/No Response |
| 88 | OTHERPROC9 | Char | Variable Name:Other Procedure 9 | Variable Name:Other Procedure | | NULL = No Procedure |
| 89 | OTHERCPT9 | Char | Other Variable Name:Other Procedure 9 | Variable Name:Other Procedure | | NULL = No Procedure |
| 90 | OTHERWRVU9 | Num | Other Work Relative Value Unit 9 | *Other Work Relative Value Unit 9 | | -99 = No Procedure/No Response |
| 91 | OTHERPROC10 | Char | Variable Name:Other Procedure 10 | Variable Name:Other Procedure | | NULL = No Procedure |
| 92 | OTHERCPT10 | Char | Other Variable Name:Other Procedure 10 | Variable Name:Other Procedure | | NULL = No Procedure |
| 93 | OTHERWRVU10 | Num | Other Work Relative Value Unit 10 | *Other Work Relative Value Unit 10 | | -99 = No Procedure/No Response |
| 94 | CONCURR1 | Char | Concurrent Procedure 1 | Variable Name:Concurrent Procedure | | NULL = No Procedure |
| 95 | CONCPT1 | Char | Concurrent CPT 1 | Variable Name:Concurrent Procedure | | NULL = No Procedure |
| 96 | CONWRVU1 | Num | Concurrent Work Relative Value Unit 1 | *Concurrent Work Relative Value Unit 1 | | -99 = No Procedure/No Response |
| 97 | CONCURR2 | Char | Concurrent Procedure 2 | Variable Name:Concurrent Procedure | | NULL = No Procedure |
| 98 | CONCPT2 | Char | Concurrent CPT 2 | Variable Name:Concurrent Procedure | | NULL = No Procedure |
| 99 | CONWRVU2 | Num | Concurrent Work Relative Value Unit 2 | *Concurrent Work Relative Value Unit 2 | | -99 = No Procedure/No Response |
| 100 | CONCURR3 | Char | Concurrent Procedure 3 | Variable Name:Concurrent Procedure | | NULL = No Procedure |
| 101 | CONCPT3 | Char | Concurrent CPT 3 | Variable Name:Concurrent Procedure | | NULL = No Procedure |
| 102 | CONWRVU3 | Num | Concurrent Work Relative Value Unit 3 | *Concurrent Work Relative Value Unit 3 | | -99 = No Procedure/No Response |
| 103 | CONCURR4 | Char | Concurrent Procedure 4 | Variable Name:Concurrent Procedure | | NULL = No Procedure |
| 104 | CONCPT4 | Char | Concurrent CPT 4 | Variable Name:Concurrent Procedure | | NULL = No Procedure |
| 105 | CONWRVU4 | Num | Concurrent Work Relative Value Unit 4 | *Concurrent Work Relative Value Unit 4 | | -99 = No Procedure/No Response |
| 106 | CONCURR5 | Char | Concurrent Procedure 5 | Variable Name:Concurrent Procedure | | NULL = No Procedure |
| 107 | CONCPT5 | Char | Concurrent CPT 5 | Variable Name:Concurrent Procedure | | NULL = No Procedure |
| 108 | CONWRVU5 | Num | Concurrent Work Relative Value Unit 5 | *Concurrent Work Relative Value Unit 5 | | -99 = No Procedure/No Response |
| 109 | CONCURR6 | Char | Concurrent Procedure 6 | Variable Name:Concurrent Procedure | | NULL = No Procedure |
| 110 | CONCPT6 | Char | Concurrent CPT 6 | Variable Name:Concurrent Procedure | | NULL = No Procedure |
| 111 | CONWRVU6 | Num | Concurrent Work Relative Value Unit 6 | *Concurrent Work Relative Value Unit 6 | | -99 = No Procedure/No Response |
| 112 | CONCURR7 | Char | Concurrent Procedure 7 | Variable Name:Concurrent Procedure | | NULL = No Procedure |
| 113 | CONCPT7 | Char | Concurrent CPT 7 | Variable Name:Concurrent Procedure | | NULL = No Procedure |

| Position # | Variable Name | Data Type | Variable Label | Search Term in Chapter 4 Notes: 'Variable Name:' needs to be included in Search Term; *Variables not included in Chap 4 | Variable Options at Entry | Comments |
|---|---|---|---|---|---|---|
| 114 | CONWRVU7 | Num | Concurrent Work Relative Value Unit 7 | *Concurrent Work Relative Value Unit 7 | | -99 = No Procedure/No Response |
| 115 | CONCURR8 | Char | Concurrent Procedure 8 | Variable Name:Concurrent Procedure | | NULL = No Procedure |
| 116 | CONCPT8 | Char | Concurrent CPT 8 | Variable Name:Concurrent Procedure | | NULL = No Procedure |
| 117 | CONWRVU8 | Num | Concurrent Work Relative Value Unit 8 | *Concurrent Work Relative Value Unit 8 | | -99 = No Procedure/No Response |
| 118 | CONCURR9 | Char | Concurrent Procedure 9 | Variable Name:Concurrent Procedure | | NULL = No Procedure |
| 119 | CONCPT9 | Char | Concurrent CPT 9 | Variable Name:Concurrent Procedure | | NULL = No Procedure |
| 120 | CONWRVU9 | Num | Concurrent Work Relative Value Unit 9 | *Concurrent Work Relative Value Unit 9 | | -99 = No Procedure/No Response |
| 121 | CONCURR10 | Char | Concurrent Procedure 10 | Variable Name:Concurrent Procedure | | NULL = No Procedure |
| 122 | CONCPT10 | Char | Concurrent CPT 10 | Variable Name:Concurrent Procedure | | NULL = No Procedure |
| 123 | CONWRVU10 | Num | Concurrent Work Relative Value Unit 10 | *Concurrent Work Relative Value Unit 10 | | -99 = No Procedure/No Response |
| 124 | EMERGNCY | Char | Emergency case | Variable Name:Emergency Case | Yes, No | NULL = No Response |
| 125 | WNDCLAS | Char | Wound classification | Variable Name; Wound Classification | 1-Clean<br>2-Clean/Contaminated<br>3-Contaminated<br>4-Dirty/Infected | NULL = No Response |
| 126 | ASACLAS | Char | ASA classification | Variable Name:ASA Classification | 1 -No Disturb<br>2 -Mild Disturb<br>3 -Severe Disturb<br>4 -Life Threat<br>5 -Moribund<br>None assigned | NULL= No Response |
| 127 | MORTPROB | Num | Estimated Probability of Mortality | *Probability of mortality is developed for all cases based on a logistic regression analysis using the patient's preoperative characteristics as the independent or predictive variables. Only cases included in the logistic regression analysis will have the associated probabilities of mortality | | System missing = case was not included in the logistic regression analysis |
| 128 | MORBPROB | Num | Estimated Probability of Morbidity | *Probability of morbidity is developed for all cases based on a logistic regression analysis using the patient's preoperative characteristics as the independent or predictive variables. Only cases included in the logistic regression analysis will have the associated probabilities of morbidity. | | System missing = case was not included in the logistic regression analysis |
| 129 | OPTIME | Num | Total operation time | *Total operation time in minutes | | -99 = No Response |
| 130 | HDISDT | Num | Hospital discharge Year | Variable Name:Acute Hospital Discharge Date | | -99 = No Response |
| 131 | YRDEATH | Num | Year of death | Variable Name:Date of Death | | -99 = Patient alive at 30 days<br>Notes: include death >30days of procedure |
| 132 | TOTHLOS | Num | Length of total hospital stay | *Length of total hospital stay | | -99 = No Response |
| 133 | AdmQtr | Num | Quarter of Admission | Variable Name:Hospital Admission Date | 1, 2, 3, 4 | -99 = No Response |
| 134 | HtoODay | Num | Days from Hospital Admission to Operation | *Days from Hospital Admission to Operation | | -99 = No Response |
| 135 | NSUPINFEC | Num | Number of Superficial Incisional SSI Occurrences | *Number of Superficial Incisional SSI Occurrences | | |
| 136 | SUPINFEC | Char | Occurrences Superficial surgical site infection | Variable Name:Superficial Incisional SSI | No Complication; Superficial Incisional SSI | |
| 137 | SSSIPATOS | Char | Superficial Incisional SSI PATOS | Variable Name:Superficial Incisional SSI – PATOS | Yes, No | NULL = No response |
| 138 | DSUPINFEC | Num | Days from Operation until Superficial Incisional SSI Complication | *Days from Operation until Superficial Incisional SSI Complication | | |
| 139 | NWNDINFD | Num | Number of Deep Incisional SSI Occurrences | *Number of Deep Incisional SSI Occurrences | | |
| 140 | WNDINFD | Char | Occurrences Deep Incisional SSI | Variable Name:Deep Incisional SSI | Deep Incisional SSI; No Complication | |
| 141 | DSSIPATOS | Char | Deep Incisional SSI PATOS | Variable Name:Deep Incisional SSI – PATOS | Yes, No | NULL = No response |
| 142 | DWNDINFD | Num | Days from Operation until Deep Incisional SSI Complication | *Days from Operation until Deep Incisional SSI Complication | | -99 = Patient did not experience this complication at or before 30 days post operation |
| 143 | NORGSPCSSI | Num | Number of Organ/Space SSI Occurrences | *Number of Organ/Space SSI Occurrences | | |
| 144 | ORGSPCSSI | Char | Occurrences Organ Space SSI | Variable Name:Organ/Space SSI | Organ/Space SSI; No Complication | |
| 145 | OSSIPATOS | Char | Organ/Space SSI PATOS | Variable Name:Organ/Space SSI – PATOS | Yes, No | NULL = No response |
| 146 | DORGSPCSSI | Num | Days from Operation until Organ/Space SSI Complication | *Days from Operation until Organ/Space SSI Complication | | -99 = Patient did not experience this complication at or before 30 days post operation |
| 147 | NDEHIS | Num | Number of Wound Disruption Occurrences | *Number of Wound Disruption Occurrences | | |
| 148 | DEHIS | Char | Occurrences Wound Disrupt | Variable Name:Wound Disruption | Wound Disruption; No Complication | |
| 149 | DDEHIS | Num | Days from Operation until Wound Disruption Complication | *Days from Operation until Wound Disruption Complication | | -99 = Patient did not experience this complication at or before 30 days post operation |
| 150 | NOUPNEUMO | Num | Number of Pneumonia Occurrences | *Number of Pneumonia Occurrences | | |
| 151 | OUPNEUMO | Char | Occurrences Pneumonia | Variable Name:Pneumonia | Pneumonia; No Complication | |
| 152 | PNAPATOS | Char | Pneumonia PATOS | Variable Name:Pneumonia – PATOS | Yes, No | NULL = No response |

| Position # | Variable Name | Data Type | Variable Label | Search Term in Chapter 4<br>Notes: 'Variable Name:' needs to be included in Search Term;<br>*Variables not included in Chap 4 | Variable Options at Entry | Comments |
|---|---|---|---|---|---|---|
| 153 | DOUPNEUMO | Num | Days from Operation until Pneumonia Complication | *Days from Operation until Pneumonia Complication | | -99 = Patient did not experience this complication at or before 30 days post operation |
| 154 | NREINTUB | Num | Number of Unplanned Intubation Occurrences | *Number of Unplanned Intubation Occurrences | | |
| 155 | REINTUB | Char | Occurrences Unplanned Intubation | Variable Name:Unplanned Intubation | Unplanned Intubation; No Complication | |
| 156 | DREINTUB | Num | Days from Operation until Unplanned Intubation Complication | *Days from Operation until Unplanned Intubation Complication | | -99 = Patient did not experience this complication at or before 30 days post operation |
| 157 | NPULEMBOL | Num | Number of Pulmonary Embolism Occurrences | *Number of Pulmonary Embolism Occurrences | | |
| 158 | PULEMBOL | Char | Occurrences Pulmonary Embolism | Variable Name:Pulmonary Embolism | Pulmonary Embolism; No Complication | |
| 159 | DPULEMBOL | Num | Days from Operation until Pulmonary Embolism Complication | *Days from Operation until Pulmonary Embolism Complication | | -99 = Patient did not experience this complication at or before 30 days post operation |
| 160 | NFAILWEAN | Num | Number of On Ventilator > 48 Hours Occurrences | *Number of On Ventilator > 48 Hours Occurrences | | |
| 161 | FAILWEAN | Char | Occurrences Ventilator > 48Hours | Variable Name:On Ventilator > 48 Hours | On Ventilator greater than 48 Hours; No Complication | |
| 162 | VENTPATOS | Char | On Ventilator > 48 Hours PATOS | Variable Name:On Ventilator > 48 Hours – PATOS | Yes; No | NULL = No response |
| 163 | DFAILWEAN | Num | Days from Operation until On Ventilator > 48 Hours Complication | *Days from Operation until On Ventilator > 48 Hours Complication | | -99 = Patient did not experience this complication at or before 30 days post operation |
| 164 | NRENAINSF | Num | Number of Progressive Renal Insufficiency Occurrences | *Number of Progressive Renal Insufficiency Occurrences | | |
| 165 | RENAINSF | Char | Occurrences Progressive Renal Insufficiency | Variable Name:Progressive Renal Insufficiency/Acute Renal Failure Requiring Dialysis | Progressive Renal Insufficiency; No Complication | |
| 166 | DRENAINSF | Num | Days from Operation until Progressive Renal Insufficiency Complication | *Days from Operation until Progressive Renal Insufficiency Complication | | -99 = Patient did not experience this complication at or before 30 days post operation |
| 167 | NOPRENAFL | Num | Number of Acute Renal Failure Occurrences | *Number of Acute Renal Failure Occurrences | | |
| 168 | OPRENAFL | Char | Occurrences Acute Renal Fail | Variable Name:Progressive Renal Insufficiency/Acute Renal Failure Requiring Dialysis | Acute Renal Failure; No Complication | |
| 169 | DOPRENAFL | Num | Days from Operation until Acute Renal Failure Complication | *Days from Operation until Acute Renal Failure Complication | | -99 = Patient did not experience this complication at or before 30 days post operation |
| 170 | NURNINFEC | Num | Number of Urinary Tract infection Occurrences | *Number of Urinary Tract infection Occurrences | | |
| 171 | URNINFEC | Char | Occurrences Urinary Tract Infection | Variable Name:Urinary Tract Infection | Urinary Tract Infection; No Complication | |
| 172 | UTIPATOS | Char | UTI PATOS | Variable Name:UTI – PATOS | Yes; No | NULL = No response |
| 173 | DURNINFEC | Num | Days from Operation until Urinary Tract Infection Complication | *Days from Operation until Urinary Tract Infection Complication | | -99 = Patient did not experience this complication at or before 30 days post operation |
| 174 | NCNSCVA | Num | Number of Stroke/CVA Occurrences | *Number of Stroke/CVA Occurrences | | |
| 175 | CNSCVA | Char | CVA/Stroke with neurological deficit | Variable Name:Stroke/Cerebral Vascular Accident (CVA) | Stroke/CVA; No Complication | |
| 176 | DCNSCVA | Num | Days from Operation until Stroke/CVA Complication | *Days from Operation until Stroke/CVA Complication | | -99 = Patient did not experience this complication at or before 30 days post operation |
| 177 | NCDARREST | Num | Number of Cardiac Arrest Requiring CPR Occurrences | *Number of Cardiac Arrest Requiring CPR Occurrences | | |
| 178 | CDARREST | Char | Occurrences Cardiac Arrest Requiring CPR | Variable Name:Intraoperative or Postoperative Cardiac Arrest Requiring CPR | Cardiac Arrest Requiring CPR; No Complication | |
| 179 | DCDARREST | Num | Days from Operation until Cardiac Arrest Requiring CPR Complication | *Days from Operation until Cardiac Arrest Requiring CPR Complication | | -99 = Patient did not experience this complication at or before 30 days post operation |
| 180 | NCDMI | Num | Number of Myocardial Infarction Occurrences | *Number of Myocardial Infarction Occurrences | | |
| 181 | CDMI | Char | Occurrences Myocardial Infarction | Variable Name:Intraoperative or Postoperative Myocardial Infarction | Myocardial Infarction; No Complication | |
| 182 | DCDMI | Num | Days from Operation until Myocardial Infarction Complication | *Days from Operation until Myocardial Infarction Complication | | -99 = Patient did not experience this complication at or before 30 days post operation |
| 183 | NOTHBLEED | Num | Number of Bleeding Transfusions Occurrences | *Number of Bleeding Transfusions Occurrences | | |
| 184 | OTHBLEED | Char | Occurrences Bleeding Transfusions | Variable Name:Transfusion Intra/Postop (RBC within the First 72 Hrs of Surgery Start Time) | Transfusions/Intraop/Postop; No Complication | |
| 185 | DOTHBLEED | Num | Days from Operation until Bleeding Transfusions Complication | *Days from Operation until Bleeding Transfusions Complication | | -99 = Patient did not experience this complication at or before 30 days post operation |
| 186 | NOTHDVT | Num | Number of DVT/Thrombophlebitis Occurrences | *Number of DVT/Thrombophlebitis Occurrences | | |
| 187 | OTHDVT | Char | Occurrences DVT/Thrombophlebitis | Variable Name:Vein Thrombosis Requiring Therapy | DVT Requiring Therapy; No Complication | |
| 188 | DOTHDVT | Num | Days from Operation until DVT/Thrombophlebitis Complication | *Days from Operation until DVT/Thrombophlebitis Complication | | -99 = Patient did not experience this complication at or before 30 days post operation |
| 189 | NOTHSYSEP | Num | Number of Sepsis Occurrences | *Number of Sepsis Occurrences | | |
| 190 | OTHSYSEP | Char | Occurrences Sepsis | Variable Name:Sepsis | Sepsis; No Complication | |
| 191 | SEPSISPATOS | Char | Sepsis PATOS | Variable Name:Sepsis – PATOS | Yes; No | NULL = No Response |

| Position # | Variable Name | Data Type | Variable Label | Search Term in Chapter 4<br>Notes: 'Variable Name:' needs to be included in Search Term;<br>*Variables not included in Chap 4 | Variable Options at Entry | Comments |
|---|---|---|---|---|---|---|
| 192 | DOTHSYSEP | Num | Days from Operation until Sepsis Complication | *Days from Operation until Sepsis Complication | | -99 = Patient did not experience this complication at or before 30 days post operation |
| 193 | NOTHSESHOCK | Num | Number of Septic Shock Occurrences | *Number of Septic Shock Occurrences | | |
| 194 | OTHSESHOCK | Char | Occurrences Septic Shock | Variable Name:Septic Shock | Septic Shock; No Complication | |
| 195 | SEPSHOCKPATOS | Char | Septic Shock PATOS | Variable Name:Septic Shock – PATOS | Yes; No | NULL = No Response |
| 196 | DOTHSESHOCK | Num | Days from Operation until Septic Shock Complication | *Days from Operation until Septic Shock Complication | | -99 = Patient did not experience this complication at or before 30 days post operation |
| 197 | PODIAG | Char | Post-op diagnosis (ICD 9) | Variable Name:Postoperative Diagnosis (ICD Code) | | |
| 198 | PODIAGTX | Char | Post-op Diagnosis Text | Variable Name:Postoperative Diagnosis (ICD Code) | | |
| 199 | PODIAG10 | Char | Post-op diagnosis (ICD 10) | Variable Name:Postoperative Diagnosis (ICD Code) | | |
| 200 | PODIAGTX10 | Char | Post-op Diagnosis Text | Variable Name:Postoperative Diagnosis (ICD Code) | | |
| 201 | RETURNOR | Char | Return to OR | Variable Name:Unplanned Reoperation | Yes; No | NULL= No Response |
| 202 | DOpertoD | Num | Days from Operation to Death | *Days from Operation to Death | | -99 = Patient did not die at or before 30 days post operation Notes: deaths within 30 days of procedure included only |
| 203 | DOptoDis | Num | Days from Operation to Discharge | *Days from Operation to Discharge | | -99 = No Response |
| 204 | STILLINHOSP | Char | Still in Hospital > 30 Days | Variable Name:Still in Hospital > 30 Days | Yes; No | NULL = No Response |
| 205 | REOPERATION1 | Char | Unplanned Reoperation 1 | Variable Name:Unplanned Reoperation | Yes; No | NULL=No Response |
| 206 | RETORPODAYS | Num | Days from principal operative procedure to Unplanned Reoperation 1 | *Days from principal operative procedure to Unplanned Reoperation 1 | | -99 = Patient did not experience Unplanned Reoperation 1 |
| 207 | REOPORCPT1 | Char | Unplanned Reoperation 1 CPT | Variable Name:Unplanned Reoperation | | NULL = No Response |
| 208 | RETORRELATED | Char | Unplanned Reoperation 1 related to principal operative procedure | Variable Name:Unplanned Reoperation | Yes<br>No<br>Unknown | NULL = No Response |
| 209 | REOPORICD91 | Char | Unplanned Reoperation 1 ICD-9 | Variable Name:Unplanned Reoperation | | NULL = No Response |
| 210 | REOPOR1ICD101 | Char | Unplanned Reoperation 1 ICD-10 | Variable Name:Unplanned Reoperation | | |
| 211 | REOPERATION2 | Char | Unplanned Reoperation 2 | Variable Name:Unplanned Reoperation | Yes; No | NULL=No Response |
| 212 | RETOR2PODAYS | Num | Days from principal operative procedure to Unplanned Reoperation 2 | *Days from principal operative procedure to Unplanned Reoperation 2 | | -99 = Patient did not experience Unplanned Reoperation 2 |
| 213 | REOPOR2CPT1 | Char | Unplanned Reoperation 2 CPT | Variable Name:Unplanned Reoperation | | NULL = No Response |
| 214 | RETOR2RELATED | Char | Unplanned Reoperation 2 related to principal operative procedure | Variable Name:Unplanned Reoperation | Yes<br>No<br>Unknown | NULL = No Response |
| 215 | REOPOR2ICD91 | Char | Unplanned Reoperation 2 ICD-9 | Variable Name:Unplanned Reoperation | | NULL = No Response |
| 216 | REOPOR2ICD101 | Char | Unplanned Reoperation 2 ICD-10 | Variable Name:Unplanned Reoperation | | NULL = No Response |
| 217 | REOPERATION3 | Char | More than 2 unplanned reoperations | Variable Name:Unplanned Reoperation | Yes; No | NULL=No Response |
| 218 | READMISSION1 | Char | Any Readmission 1 | Variable Name:Hospital Readmission | Yes; No | NULL=No Response |
| 219 | READMPODAYS1 | Num | Days from principal operative procedure to Any Readmission 1 | *Days from principal operative procedure to Any Readmission 1 | | -99 = Patient did not experience Any Readmission 1 |
| 220 | UNPLANNEDREADMISSION1 | Char | Unplanned Readmission 1 | Variable Name:Hospital Readmission | Yes; No | NULL = No Response |
| 221 | READMRELATED1 | Char | Unplanned Readmission 1 likely related to the principal procedure | Variable Name:Hospital Readmission | Yes; No | NULL = No Response |
| 222 | READMSUSPREASON1 | Char | Readmission related suspected reason 1 | Variable Name:Hospital Readmission | Superficial Incisional SSI<br>Deep Incisional SSI<br>Organ/Space SSI<br>Wound Disruption<br>Pneumonia<br>Unplanned Intubation<br>Pulmonary Embolism<br>On Ventilator > 48 hours<br>Progressive Renal Insufficiency<br>Acute Renal Failure<br>Urinary Tract Infection<br>CVA<br>Cardiac Arrest Requiring CPR<br>Myocardial Infarction<br>Bleeding Requiring Transfusion (72h of surgery start time)<br>Vein Thrombosis Requiring Therapy<br>Sepsis<br>Septic Shock<br>Other (list ICD 9 code)<br>Other (list ICD 10 code)<br>C. diff | NULL = No Response |

| Position # | Variable Name | Data Type | Variable Label | Search Term in Chapter 4<br>Notes: 'Variable Name:' needs to be included in Search Term;<br>*Variables not included in Chap 4 | Variable Options at Entry | Comments |
|---|---|---|---|---|---|---|
| 223 | READMUNRELSUSP1 | Char | Readmission unrelated suspected reason 1 | Variable Name:Hospital Readmission | Superficial Incisional SSI<br>Deep Incisional SSI<br>Organ/Space SSI<br>Wound Disruption<br>Pneumonia<br>Unplanned Intubation<br>Pulmonary Embolism<br>On Ventilator > 48 hours<br>Progressive Renal Insufficiency<br>Acute Renal Failure<br>Urinary Tract Infection<br>CVA<br>Cardiac Arrest Requiring CPR<br>Myocardial Infarction<br>Bleeding Requiring Transfusion (72h of surgery start time)<br>Vein Thrombosis Requiring Therapy<br>Sepsis<br>Septic Shock<br>Other (list ICD 9 code)<br>Other (list ICD 10 code)<br>C. diff | NULL = No Response |
| 224 | READMRELICD91 | Char | Readmission related ICD-9 code 1 | Variable Name:Hospital Readmission | | NULL = No Response |
| 225 | READMRELICD101 | Char | Readmission related ICD-10 code 1 | Variable Name:Hospital Readmission | | NULL = No Response |
| 226 | READMUNRELICD91 | Char | Readmission unrelated ICD-9 code 1 | Variable Name:Hospital Readmission | | NULL = No Response |
| 227 | READMUNRELICD101 | Char | Readmission unrelated ICD-10 code 1 | Variable Name:Hospital Readmission | | NULL = No Response |
| 228 | READMISSION2 | Char | Any Readmission 2 | Variable Name:Hospital Readmission | Yes; No | |
| 229 | READMPODAYS2 | Num | Days from principal operative procedure to Any Readmission 2 | *Days from principal operative procedure to Any Readmission 2 | | -99 = Patient did not experience Any Readmission 2 |
| 230 | UNPLANNEDREADMISSION2 | Char | Unplanned Readmission 2 | Variable Name:Hospital Readmission | Yes;No | NULL = No Response |
| 231 | READMRELATED2 | Char | Unplanned Readmission 2 likely related to the principal procedure | Variable Name:Hospital Readmission | Yes;No | NULL = No Response |
| 232 | READMSUSPREASON2 | Char | Readmission related suspected reason 2 | Variable Name:Hospital Readmission | See *Readmission related suspected reason 1* | NULL = No Response |
| 233 | READMUNRELSUSP2 | Char | Readmission unrelated suspected reason 2 | Variable Name:Hospital Readmission | See *Readmission unrelated suspected reason 1* | NULL = No Response |
| 234 | READMRELICD92 | Char | Readmission related ICD-9 code 2 | Variable Name:Hospital Readmission | | NULL = No Response |
| 235 | READMRELICD102 | Char | Readmission related ICD-10 code 2 | Variable Name:Hospital Readmission | | NULL = No Response |
| 236 | READMUNRELICD92 | Char | Readmission unrelated ICD-9 code 2 | Variable Name:Hospital Readmission | | NULL = No Response |
| 237 | READMUNRELICD102 | Char | Readmission unrelated ICD-10 code 2 | Variable Name:Hospital Readmission | | NULL = No Response |
| 238 | READMISSION3 | Char | Any Readmission 3 | Variable Name:Hospital Readmission | Yes; No | |
| 239 | READMPODAYS3 | Num | Days from principal operative procedure to Any Readmission 3 | *Days from principal operative procedure to Any Readmission 3 | | -99 = Patient did not experience Any Readmission 3 |
| 240 | UNPLANNEDREADMISSION3 | Char | Unplanned Readmission 3 | Variable Name:Hospital Readmission | Yes;No | NULL = No Response |
| 241 | READMRELATED3 | Char | Unplanned Readmission 3 likely related to the principal procedure | Variable Name:Hospital Readmission | Yes; No | NULL = No Response |
| 242 | READMSUSPREASON3 | Char | Readmission related suspected reason 3 | Variable Name:Hospital Readmission | See *Readmission related suspected reason 1* | NULL = No Response |
| 243 | READMUNRELSUSP3 | Char | Readmission unrelated suspected reason 3 | Variable Name:Hospital Readmission | See *Readmission unrelated suspected reason 1* | NULL = No Response |
| 244 | READMRELICD93 | Char | Readmission related ICD-9 code 3 | Variable Name:Hospital Readmission | | NULL = No Response |
| 245 | READMRELICD103 | Char | Readmission related ICD-10 code 3 | Variable Name:Hospital Readmission | | NULL = No Response |
| 246 | READMUNRELICD93 | Char | Readmission unrelated ICD-9 code 3 | Variable Name:Hospital Readmission | | NULL = No Response |
| 247 | READMUNRELICD103 | Char | Readmission unrelated ICD-10 code 3 | Variable Name:Hospital Readmission | | NULL = No Response |
| 248 | READMISSION4 | Char | Any Readmission 4 | Variable Name:Hospital Readmission | Yes; No | |
| 249 | READMPODAYS4 | Num | Days from principal operative procedure to Any Readmission 4 | *Days from principal operative procedure to Any Readmission 4 | | -99 = Patient did not experience Any Readmission 4 |
| 250 | UNPLANNEDREADMISSION4 | Char | Unplanned Readmission 4 | Variable Name:Hospital Readmission | Yes; No | NULL = No Response |
| 251 | READMRELATED4 | Char | Unplanned Readmission 4 likely related to the principal procedure | Variable Name:Hospital Readmission | Yes; No | NULL = No Response |
| 252 | READMSUSPREASON4 | Char | Readmission related suspected reason 4 | Variable Name:Hospital Readmission | See *Readmission related suspected reason 1* | NULL = No Response |
| 253 | READMUNRELSUSP4 | Char | Readmission unrelated suspected reason 4 | Variable Name:Hospital Readmission | See *Readmission unrelated suspected reason 1* | NULL = No Response |
| 254 | READMRELICD94 | Char | Readmission related ICD-9 code 4 | Variable Name:Hospital Readmission | | NULL = No Response |
| 255 | READMRELICD104 | Char | Readmission related ICD-10 code 4 | Variable Name:Hospital Readmission | | NULL = No Response |
| 256 | READMUNRELICD94 | Char | Readmission unrelated ICD-9 code 4 | Variable Name:Hospital Readmission | | NULL = No Response |
| 257 | READMUNRELICD104 | Char | Readmission unrelated ICD-10 code 4 | Variable Name:Hospital Readmission | | NULL = No Response |
| 258 | READMISSION5 | Char | Any Readmission 5 | Variable Name:Hospital Readmission | Yes; No | |
| 259 | READMPODAYS5 | Num | Days from principal operative procedure to Any Readmission 5 | *Days from principal operative procedure to Any Readmission 5 | | -99 = Patient did not experience Any Readmission 5 |
| 260 | UNPLANNEDREADMISSION5 | Char | Unplanned Readmission 5 | Variable Name:Hospital Readmission | Yes; No | NULL = No Response |
| 261 | READMRELATED5 | Char | Unplanned Readmission 5 likely related to the principal procedure | Variable Name:Hospital Readmission | Yes; No | NULL = No Response |

| Position # | Variable Name | Data Type | Variable Label | Search Term in Chapter 4 Notes: 'Variable Name' needs to be included in Search Term; *Variables not included in Chap 4 | Variable Options at Entry | Comments |
|---|---|---|---|---|---|---|
| 262 | READMSUSPREASON5 | Char | Readmission related suspected reason 5 | Variable Name:Hospital Readmission | See "Readmission related suspected reason 1" | NULL = No Response |
| 263 | READMUNRELSUSP5 | Char | Readmission unrelated suspected reason 5 | Variable Name:Hospital Readmission | See "Readmission unrelated suspected reason 1" | NULL = No Response |
| 264 | READMRELICD95 | Char | Readmission related ICD-9 code 5 | Variable Name:Hospital Readmission | | NULL = No Response |
| 265 | READMRELICD105 | Char | Readmission related ICD-10 code 5 | Variable Name:Hospital Readmission | | NULL = No Response |
| 266 | READMUNRELICD95 | Char | Readmission unrelated ICD-9 code 5 | Variable Name:Hospital Readmission | | NULL = No Response |
| 267 | READMUNRELICD105 | Char | Readmission unrelated ICD-10 code 5 | Variable Name:Hospital Readmission | | NULL = No Response |
| 268 | WOUND_CLOSURE | Char | Surgical wound closure | Variable Name:Surgical Wound(s) Closure | All layers of incision (deep and superficial) fully closed<br>Only deep layers closed; superficial left open<br>No layers of incision are surgically closed | NULL=No Response |
| 269 | PODIAG_OTHER | Char | Other postoperative occurrence(ICD 9) | Variable Name:Other Postoperative Occurrence (ICD Code) | | NULL=No Response |
| 270 | PODIAG_OTHER10 | Char | Other postoperative occurrence(ICD 10) | Variable Name:Other Postoperative Occurrence (ICD Code) | | NULL=No Response |
| 271 | ANESTHES_OTHER | Char | Additional anesthesia technique | Variable Name:Additional Anesthesia Technique(s) | General<br>Epidural<br>Spinal<br>Regional<br>Local<br>Monitored Anesthesia Care/IV Sedation<br>Other | NULL = No Response |
| 272 | OTHCDIFF | Char | Occurrences Clostridium Difficile (C.diff) Colitis | Variable Name:Postoperative Clostridium Difficile (C.diff) Colitis | No Complication; C. diff | |
| 273 | NOTHCDIFF | Num | Number of C. diff Occurrences | *Number of C. diff Colitis Occurrences | | |
| 274 | DOTHCDIFF | Num | Days from operation until C.diff Complication | *Days from operation til C. diff Colitis Complication | | -99=Patient did not experience complication at or before 30 days post operations |

# APPENDIX 3. Exclusion Criteria NSQIP

Exhaustive list of Case and Hospital Exclusion Criteria, quoted directly from the ACS NSQIP 2017 PUF USER GUIDE

***Case Exclusion Criteria***

The following exclusion criteria were applied to cases collected in 2017. For the current inclusion/exclusion criteria please contact the ACS NSQIP Clinical Support Team at clinicalsupport@acsnsqip.org.

- • Minor Cases (all cases that are not considered Major)
- • Patients under the age of 18 years.
- • Patient for the case in question has been assigned with an ASA score of 6 (brain-death organ donors).
- • Cases involving Hyperthermic Intraperitoneal Chemotherapy (HIPEC)
- • Trauma cases: Any patient that meets the trauma exclusion criteria will be excluded.
- • Transplant cases: For any patient who is admitted to the hospital and has a transplant procedure, that transplant procedure and any additional surgical procedure during the transplant hospitalization will be excluded.

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• Cases beyond three per cycle for limited cases: For each program option (excluding Small & Rural), only a maximum of three cases from each of the below procedures should be included per 8-day cycle. Any case beyond the case limit of three for any of these procedures should be excluded.

o Inguinal Herniorrhaphies
o Breast Lumpectomies
o Laparoscopic Cholecystectomies o TURPs and/or TURBTs

*(This limit does not apply for Procedure Targeted sites that are targeting TURPs.)*

- • Cases beyond the required number per your site's contract for each cycle.
- • A return to the operating room that is related to an occurrence or complication of a prior procedure
- • Multiple NSQIP assessed cases within 30 days: Any patient who already has a NSQIP-assessed procedure entered within the previous 30 days at your site should be excluded. Only one NSQIP-assessed procedure can be abstracted patient, per 30 days, for each

***Hospital Exclusion Criteria***

In addition to the case inclusion/exclusion criteria, hospital inclusion/exclusion criteria are also imposed. To maintain the highest level of data quality, only cases included in the odds ratio analysis are included in the PUF. These cases go through an additional level of scrutiny as they are passed from data collection to statistical analysis. A site is excluded from the odds ratio calculations and the PUF if it fits any of the following criteria:

- • Sites that exhibit issues with either data quality or 30-day follow-up may be excluded in order to ensure the integrity of PUF data
- • Inter-Rater Reliability Audit disagreement rate is over 5%

# APPENDIX 4. Variables Selected for Study & Variables Created

| 2011-17 Variables of Interest | Variable Description |
|---|---|
| CASEID | Case Identification Number |
| CPT | CPT |
| AAA_PAAS | Prior Open Abdominal Surgery |
| ADMYR | Year of Admission |
| AGE | Age of patient with patients over 89 coded as 90+ |
| SEX | Gender |
| HEIGHT | Height in inches |
| WEIGHT | Weight in lbs |
| SMOKE | Current smoker within one year |
| STEROID | Steroid use for chronic condition |
| ASACLAS | ASA classification |
| FNSTATUS2 | Functional health status Prior to Surgery |
| HXCHF | Congestive heart failure (CHF) in 30 days before surgery |
| HXCOPD | History of Severe COPD |
| HYPERMED | Hypertension requiring medication |
| ASCITES | Ascites |
| DIABETES | Diabetes melitus with oral agents or insulin |
| DIALYSIS | Currently on dialysis (pre-op |
| DISCANCR | Disseminated cancer |
| PRSEPIS | Systemic Sepsis |
| BLEEDIS | Bleeding disorders |
| ETHNICITY_HISPANIC | Ethnicity Hispanic |
| OPERYR | Year of Operation |
| PRNCPTX | Principal Operative Procedure CPT code description |
| AAA_SURGIND | Indication for Surgery |
| AAA_ANDIAM | Aneurysm Diameter |
| AAA_ANDIAM_UNK | Aneurysm Diameter Unknown |
| OPTIME | Total operation time |
| ELECTSURG | Elective Surgery |
| EMERGNCY | Emergency case |
| ANESTHES | Principal anesthesia technique |
| AAA_SURGAP | Surgical Approach |
| AAA_PCL | Proximal Clamp Location |

| | |
|---|---|
| AAA_CP_RENREVASC | Renal Revascularization |
| AAA_CP_VISCREVASC | Visceral (SMA & Celiac Revascularization |
| AAA_MIMA | Management of Inferior Mesenteric Artery |
| AAA_ICULOS | Intensive Care Unit LOS |
| TOTHLOS | Length of total hospital stay |
| DOPTODIS | Days from Operation to Discharge |
| DISCHDEST | Discharge Destination |
| YRDEATH | Year of death |
| DOPERTOD | Days from Operation to Death |
| AAA_COLITIS | Ischemic Colitis |
| AAA_DCOLITIS | Days from Operation to Ischemic Colitis |
| AAA_COLITIS_TREAT | Ischemic Colitis Treatment |
| OPRENAFL | Occurrences Acute Renal Fail |
| RENAFAIL | Acute renal failure (post-op) |
| DOPRENAFL | Days from Operation until Acute Renal Failure Complication |
| RENAINSF | Occurrences Progressive Renal Insufficiency |
| DRENAINSF | Days from Operation until Progressive Renal Insufficiency Complication |
| CDMI | Occurrences Myocardial Infarction |
| DCDMI | Days from Operation until Myocardial Infarction Complication |
| CNSCVA | CVA/Stroke with neurological deficit |
| DCNSCVA | Days from Operation until Stroke/CVA Complication |
| CDARREST | Occurrences Cardiac Arrest Requiring CPR |
| DCDARREST | Days from Operation until Cardiac Arrest Requiring CPR Complication |
| OUPNEUMO | Occurrences Pneumonia |
| DOUPNEUMO | Days from Operation until Pneumonia Complication |
| PULEMBOL | Occurrences Pulmonary Embolism |
| DPULEMBOL | Days from Operation until Pulmonary Embolism Complication |
| URNINFEC | Occurrences Urinary Tract Infection |
| DURNINFEC | Days from Operation until Urinary Tract Infection Complication |
| OTHBLEED | Occurrences Bleeding Transfusions |
| DOTHBLEED | Days from Operation until Bleeding Transfusions Complication |
| OTHDVT | Occurrences DVT/Thrombophlebitis |
| DOTHDVT | Days from Operation until DVT/Thrombophlebtis Complication |

| | |
|---|---|
| DEHIS | Occurrences Wound Disrupt |
| DDEHIS | Days from Operation until Wound Disruption Complication |
| WOUND_CLOSURE | Surgical wound closure |
| SUPINFEC | Occurrences Superficial surgical site infection |
| DSUPINFEC | Days from Operation until Superficial Incisional SSI Complication |
| WNDINFD | Occurrences Deep Incisional SSI |
| DWNDINFD | Days from Operation until Deep Incisional SSI Complication |
| ORGSPCSSI | Occurrences Organ Space SSI |
| DORGSPCSSI | Days from Operation until Organ/Space SSI Complication |
| OTHSYSEP | Occurrences Sepsis |
| DOTHSYSEP | Days from Operation until Sepsis Complication |
| OTHSESHOCK | Occurrences Septic Shock |
| DOTHSESHOCK | Days from Operation until Septic Shock Complication |
| READMISSION1 | Any Readmission 1 |
| UNPLANNEDREADMISSION1 | Unplanned Readmission 1 |
| RETURNOR | Return to OR |
| REOPERATION1 | Unplanned Reoperation 1 |
| PRALBUM | Pre-operative serium albumin |
| PRALKPH | Pre-operative alkaline phosphatase |
| PRBILI | Pre-operative total bilirubin |
| PRBUN | Pre-operative BUN |
| PRCREAT | Pre-operative serium creatinine |
| PRHCT | Pre-operative hematocrit |
| PRINR | Pre-operative International Normalized Ratio (INR) of PT values |
| PRPLATE | Pre-operative platelet count |
| PRPT | Pre-operative PT |
| PRPTT | Pre-operative PTT |
| PRSGOT | Pre-operative SGOT |
| PRSODM | Pre-operative serium sodium |
| PRWBC | Pre-operative WBC |

| created variable | Method |
|---|---|
| MORT30D | Any valid entry >0 in the days till death DOPERTOD variable = 'yes' |
| BMI | (lb/in²)x703 |
| VAL_COL_TTT | Patient had ischemic colitis and has a valid treatment input |
| SURGAPRABD | Transperitoneal midline and transverse are pooled |
| Diabetes_Yes_No | pooling diabetes patients with and without insulin into yes group, no diabetes in no group |
| AAA_SURGIND_POOL | pooling of surgical indications from 11 groups to 7 |
| ASA numerical | ASA numerical |
| ProcedurePOOL | uniformisation |
| Return OR POOL | RETURN OR yes + Colitis surgical treatment yes + Lower extremity ischemia requiring reintervention yes |
| Any Complication | Any of the above postop complications (except OR time and mortality, and bleeding with transfusion) |
| Any SSI | SSSI, DSSI, OSSI |
| DESTDISCHPOOL | pooled destination discharge |
| OPTIMEMED | Operating time above or below median 230min |
| PO_COMP_ANY | all postop complication compiled except bleeds |
| PO_ABDCOMP | AAA_COLITIS, OPRENAFL, DEHIS, WNDINFD, ORFDPCSSI |
| PO_BLEED | Any OTHBLEED with OTHBLEED >=1 |

# APPENDIX 5. Complete intraoperative Results

| **Variable** | | nonPAS | PAS | p | test |
|---|---|---|---|---|---|
| **Proximal clamp location** | infrarenal(%) | 61,1 | 59,1 | 0,324 | $X^2$ |
| | above one | 21,6 | 24,7 | | |
| | suprarenal | 17,3 | 16,2 | | |
| | | | | | |
| **OP Time** | after removing undocumented (10) | | | | |
| | average | 249,3 | 261,9 | 0,032 | Mann-Whitney-U-Test |
| | median | 227 | 237 | p<0,2 | |
| | IQR: 126 | 125 | 133 | | |
| | | | | | |
| **Surgical Approach** | after removing unknown (22) and pooling trans vs retro | | | | |
| | trans (%) | 77,6 | 69,7 | 0,000 | $X^2$ |
| | retro | 22,4 | 30,3 | p<0,2 | |
| | | | | | |
| **Revascularisation** | | | | | |
| **Renal** | yes(%) | 9 | 9,5 | 0,768 | $X^2$ |
| | no | 91 | 90,5 | | |
| **Visceral:SMA and/or Celiac** | yes(%) | 2,4 | 3,5 | 0,172 | $X^2$ |
| | no | 97,6 | 96,5 | p<0,2 | |
| **IMA** | after removing 913 not documented | | | | |
| | implanted(%) | 7,7 | 10,2 | 0,225 | $X^2$ |
| | ligated | 75,7 | 76,6 | | |
| | chronically occluded | 16,6 | 13,2 | | |
| | | | | | |
| **Procedure Pooled** | | | | | |
| | AO(%)51,4 | 50,3 | 54,5 | 0,001 | $X^2$ |
| | AO&Iliac32,3 | 34,4 | 26,5 | p<0,2 | |
| | AO&Visc13,4 | 13 | 14,5 | | |
| | AotoBifem2,9 | 2,3 | 4,4 | | |
| | | | | | |

## APPENDIX 6. Subgroup Analysis Male Patients Only

In order to definitively exclude the possibility that previous gynecological surgery in women may be skewing the results to insignificance, all major results were recalculated including only male patients. However there was no meaningful difference in the results:

| **Table 1: Main Univariate Results for Male Patients only** | | |
|---|---|---|
| Outcome | Comparing nPAS with PAS | p-value |
| 30day mortality | Pearson Chi=0.131 | 0.72 |
| Ischemic Colitis | Pearson Chi=3.973 | 0.05 |
| OP Time | Mean difference 17min | 0.01 |

| **Table 2: Logistic Regression for 30day Mortality for Male Patients only** | | | |
|---|---|---|---|
| | Odds Ratio | 95% CI | p-value |
| **Prior open abdominal surgery PAS** | **0.71** | **0.33, 1.43** | **0.39** |
| Age | 1.07 | 1.02, 1.12 | **<0.01** |
| BMI | 0.98 | 0.92, 1.04 | 0.48 |
| ASA | 1.85 | 1.02, 3.35 | 0.04 |
| Functional Status | 4.04 | 0.95, 17.07 | 0.06 |
| Smoker | 0.49 | 0.25, 1.05 | 0.07 |
| On Steroids | 0.87 | 0.17, 4.37 | 0.87 |
| CHF | 3.10 | 0.85, 11.3 | 0.09 |
| Severe COPD | 3.03 | 1.58, 5.79 | **<0.01** |
| AHT | 1.03 | 0.43, 2.43 | 0.95 |
| Dialysis | 6.37 | 0.71, 56,78 | 0.10 |
| Disseminated cancer | 7.81 | 0.52, 117.04 | 0.14 |
| Bleeding disorders | 1.88 | 0.70, 5.03 | 0.21 |
| Surgical indication | 0.94 | 0.72, 1.22 | 0.64 |
| proximal extent | 1.39 | 1.06, 1.83 | 0.02 |
| OP Time | 1.00 | 1.00, 1.01 | **<0.01** |

| Table 3: Logistic Regression for Ischemic Colitis for Male Patients only | | | |
|---|---|---|---|
| | Odds Ratio | 95% Confidence Interval | p-value |
| **Prior open abdominal surgery PAS** | **1.64** | **0.83, 3.23** | **0.16** |
| ASA | 2.30 | 1.24, 4.26 | **<0.01** |
| On Steroids | 2.32 | 0.73, 7.36 | 0.16 |
| Severe COPD | 3.26 | 1.69, 6.28 | **<0.01** |
| Aneurysm diameter | 0.74 | 0.57, 0.96 | 0.02 |
| Aneurysm proximal extent | 1.34 | 1.03, 1.76 | 0.03 |
| OP Time | 1.00 | 1.00, 1.00 | 0.03 |

| Table 4: Linear Regression for Operating Time for Male Patients only | | | |
|---|---|---|---|
| | Coefficient | 95% Confidence Interval | p-value |
| **PAS** | **11.4** | **-4.13, 26.95** | **0.15** |
| Age | -1.25 | -2.03, -0.49 | **<0.01** |
| BMI | 1.99 | 0.81, 3.16 | **<0.01** |
| ASA | 8.30 | -2.65, 19.25 | 0.14 |
| Functional status | 38.9 | -12.91, 90.74 | 0.14 |
| On Steroids | 16.2 | -22.61, 55.09 | 0.42 |
| COPD | 14.67 | -2.34, 31.67 | 0.09 |
| Hypertension | 4.09 | -11.91, 20.09 | 0.62 |
| Diabetes | 10.33 | -8.44, 29.09 | 0.28 |
| Preoperative Sepsis | 25.94 | 0.61, 51.27 | 0.05 |
| Bleeding disorder | 17.78 | -6.72, 42.27 | 0.16 |
| Aneurysm diameter | 1.14 | -3.12, 5.41 | 0.60 |
| Aneurysm proximal extent | 10.20 | 3.30, 17.11 | **<0.01** |
| Aneurysm distal extent | 17.39 | 8.78, 25.99 | **<0.01** |
| Surgical indication | 6.47 | 1.00, 11.94 | 0.02 |

# APPENDIX 7. Trends over Time

1. Proportions of main outcomes & variables of interest in the context of time

| | | ADMYR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **variable** | | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **Total** | **significance** |
| | **N** | **186** | **400** | **272** | **287** | **256** | **298** | **335** | **2034** | |
| **PAAS** | No(%) | 84,9 | 78,3 | 70,2 | 69 | 64,8 | 70,8 | 73,7 | 73 | |
| | Yes | 15,1 | 21,8 | 29,8 | 31 | 35,2 | 29,2 | 26,3 | 27 | $X^2$ p:0,000 |
| **30DMortality** | deceased(%) | 3,8 | 3 | 4 | 5,2 | 3,9 | 3,4 | 5,4 | 4,1 | $X^2$ p:0,669 |
| **Ischemic Colitis** | Yes(%) | 3,8 | 3 | 2,2 | 2,4 | 5,9 | 3 | 2,7 | 3,2 | $X^2$ p:0,252 |
| **Approach** | Retro(%) | 28 | 24,3 | 20,2 | 23,7 | 30,9 | 20,1 | 24,5 | 24,2 | |
| | Trans | 71,5 | 75 | 78,3 | 75,6 | 68,8 | 77,9 | 74 | 74,7 | $X^2$ p:0,124 |
| | rest is unkown | | | | | | | | | |
| **discharge destination** | | | | | | | | | | |
| | Home/unskilled facility (%) | 72,6 | 78 | 76,5 | 76,3 | 75 | 77,5 | 80,9 | 77,1 | |
| | skilled facility | 23,1 | 19 | 19,5 | 17,8 | 20,3 | 18,8 | 14 | 18,6 | $X^2$ p:0,228 |

2. Changing Associations over time

| **variable** | | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **Total** |
|---|---|---|---|---|---|---|---|---|---|
| | **N** | **186** | **400** | **272** | **287** | **256** | **298** | **335** | **2034** |
| **30Dmortality** | PAAS NO | 3,8 | 3,5 | 3,7 | 4 | 3,6 | 4,3 | 5,7 | |
| %deceased | PAAS YES | 3,6 | 1,1 | 4,9 | 7,9 | 4,4 | 1,1 | 4,5 | |
| | $X^2$ | 0,954 | 0,253 | 0,626 | 0,178 | 0,743 | 0,174 | 0,688 | |
| | OR | 0,938(0,109 -8,105) | 0,319(0,041 -2,507) | 1,365(0,389 -4,799) | 2,027(0,712 -5,776) | 1,240(0,341 -4,515) | ,261(0,033- 2,092) | 0,793(0,254 -2,475) | |
| delta (YES-NO) | | -0,2 | -2,4 | 1,2 | 3,9 | 0,8 | -3,2 | -1,2 | |
| **OPTIME** | PAAS NO | 243,58 | 257,14 | 238,2 | 255,87 | 263,63 | 248,49 | 237,6 | |
| average | PAAS YES | 291,39 | 252,14 | 263,26 | 239,36 | 283,91 | 114,021 | 265,3 | |
| | Mann-Whitney | 0,265 | 0,69 | 0,012 | 0,99 | 0,117 | 0,636 | 0,054 | |
| delta (YES-NO) | | 47,81 | -5 | 25,06 | -16,51 | 20,28 | -134,469 | 27,7 | |
| **Ischemic Colitis** | PAAS NO | 3,8 | 2,9 | 2,6 | 2 | 4,2 | 1,9 | 1,6 | |
| %yes | PAAS YES | 3,6 | 3,4 | 1,2 | 3,4 | 8,9 | 5,7 | 5,7 | |
| | $X^2$ | 0,954 | 0,782 | 0,478 | 0,493 | 0,129 | 0,077 | 0,043 | |
| | OR | 0,938(0,109 -8,105) | 1,206(0,319 -4,556) | 0,465(0,053 -4,044) | 1,692(0,371 -7,723) | 2,216(0,776 -6,325) | 3,155(0,827- 12,044) | 3,66(0,960- 13,951) | |
| delta (YES-NO) | | -0,2 | 0,5 | -1,4 | 1,4 | 4,7 | 3,8 | 4,1 | |
| **PO_COMP_ANY** | PAAS NO | 19,6 | 22 | 24,6 | 25,3 | 19,9 | 21,3 | 20,6 | |
| %yes | PAAS YES | 32,1 | 20,7 | 28,4 | 24,7 | 23,3 | 25,3 | 36,4 | |
| | $X^2$ | 0,137 | 0,786 | 0,513 | 0,923 | 0,518 | 0,457 | 0,003 | |
| | OR | 1,941(0,801 -4,702) | 0,922(0,515 -1,653) | 1,215(0,677 -2,180) | 0,972(0,545 -1,733) | 1,227(0,660 -2,279) | 1,249(0,696- 2,241) | 2,196(1,289 -3,740) | |
| delta (YES-NO) | | 12,5 | -1,3 | 3,8 | -0,6 | 3,4 | 4 | 15,8 | |
| **Discharge Destination** (%skilled facility not home) | PAAS NO | 21,5 | 20,4 | 16,8 | 17,2 | 15,7 | 23,7 | 12,6 | |
| | PAAS YES | 32,1 | 13,8 | 25,9 | 19,1 | 28,9 | 31 | 18,2 | |
| | $X^2$ | 0,395 | 0,168 | 0,174 | 0,568 | 0,042 | 0,001 | 0,422 | |
| delta (YES-NO) | | 10,6 | -6,6 | 9,1 | 1,9 | 13,2 | 7,3 | 5,6 | |
| **ICU LOS** | PAAS NO | 3,34 | 3,57 | 3,4 | 3,25 | 3,33 | 3,04 | 2,67 | |
| average | PAAS YES | 4,29 | 3,07 | 4,05 | 3,25 | 3,54 | 3,7 | 3,7 | |
| | Mann-Whitney | 0,207 | 0,42 | 0,208 | 0,668 | 0,178 | 0,08 | 0,001 | |
| delta (YES-NO) | | 0,95 | -0,5 | 0,65 | 0 | 0,21 | 0,66 | 1,03 | |
| **Days from operation to Discharge** | PAAS NO | 8,37 | 8,88 | 9,09 | 9,52 | 9,28 | 8,71 | 8,59 | |
| average | PAAS YES | 11,64 | 7,78 | 9,89 | 8,39 | 8,91 | 8,534 | 10,23 | |
| | Mann-Whitney | 0,004 | 0,183 | 0,005 | 0,255 | 0,051 | 0,024 | 0,226 | |
| delta (YES-NO) | | 3,27 | -1,1 | 0,8 | -1,13 | -0,37 | -0,176 | 1,64 | |

# AFFADAVIT

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**Eidesstattliche Versicherung**

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Ich erkläre hiermit an Eides statt, dass ich die vorliegende Dissertation mit dem Titel:

“Impact of Previous Open Abdominal Surgery on Open Abdominal Aortic Aneurysm Repair Outcomes”

……

selbständig verfasst, mich außer der angegebenen keiner weiteren Hilfsmittel bedient und alle Erkenntnisse, die aus dem Schrifttum ganz oder annähernd übernommen sind, als solche kenntlich gemacht und nach ihrer Herkunft unter Bezeichnung der Fundstelle einzeln nachgewiesen habe.

Ich erkläre des Weiteren, dass die hier vorgelegte Dissertation nicht in gleicher oder in ähnlicher Form bei einer anderen Stelle zur Erlangung eines akademischen Grades eingereicht wurde.

Laurence Bertrand

München,30.10.2024
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- Editor's Choice – The EVAR Surveillance Paradox Summary
- Editor's Choice – Paget-Schroetter-Syndrome Systematic Reveiw and Meta-Analysis Summary
- Editor's Choice COSTLY-TLR Author; interview with Dr. Stavroulakis & Prof Dr. Saratzis
- Physician modified stent-grafts with Prof. N. Tsilimpars & Prof. V. Makaloski
  shared publication with Vaiva Dabrovskaite
- Translational Meeting: Aneurysm growth predictors, interview with Dr. Regent Lee
  shared publication with Vaiva Dabrovskaite
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- 2019 DeWu Deutsches Wundkongress Bremen:
  Interaktive Falldiskussion einer komplexen Casus Pyoderma Gangränosum
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- 2023 European Society of Vascular Surgery 37th Annual Meeting (Belfast): „ Impact of Previous Open Abdominal Surgery on Open Abdominal Aortic Repair“
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  Interaktive Falldiskussion einer komplexen Casus Pyoderma Gangränosum
- 2019 European Pediatric Surgeons Association 20th Congress
  „Diagnositc Lymph Node Biopsy – Are we missing Tuberculosis?“
  Wissenschaftlicher Poster-präsentation
- 2016 Belgian Surgical Week
  „Thoracic Impalement: A Case Report of Challenign Thoracic Trauma Surgery“
  Sieger im Wettbewerb mit interativem Fallbericht
- 2015 Belgian Surgical Week:
  „A Surgical Take on Broncho-pulmonary Aspergillus, 20years Exerience“

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