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**Endovascular versus Open Repair of Abdominal Aneurysms:
A population-based evaluation of outcomes and resource utilization in Ontario**

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**Endovascular versus Open Repair of Abdominal Aortic
Aneurysms: A population-based evaluation of outcomes
and resource utilization in Ontario**

Prasad Jetty MDCM, FRCSC

**Thesis submitted to
The Faculty of Graduate and Postdoctoral Studies
In partial fulfilment of the requirements for the
MSc degree in Epidemiology**

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Dr. Carl van Walraven
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ABSTRACT**Endovascular versus Open Repair of Abdominal Aortic Aneurysms: A population-based evaluation of outcomes and resource utilization in Ontario**Prasad Jetty MD¹, Paul Hebert MD³, Carl van Walraven MD^{2,3}

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Objective: Two large randomized trials that compared elective EndoVascular Aneurysm Repair (EVAR) with open repair for non-ruptured abdominal aortic aneurysms (AAA) have demonstrated similar long-term mortality rates but increased costs associated with EVAR. Despite these data, the use of EVAR continues to increase in North America. There are currently very limited population-based adjusted data looking at long-term outcomes and resource utilization.

Methods: All patients who underwent elective AAA repair between April 2002 and March 2007 in Ontario were identified using data from hospital discharge abstracts. ICD-10-CA and Canadian Classification of health Interventions (CCI) codes were used in a validated algorithm to identify patients who underwent either EVAR or open repair of non-ruptured AAAs. Pre-operative co-morbidities were measured using the Charlson co-morbidity index. Risk stratification into quintiles was performed using propensity score analysis.

Results: Overall, 6461 patients underwent treatment of non-ruptured AAAs (N: EVAR 888; open 5573). Patients undergoing EVAR were older and had more comorbidities. The adjusted 30-day mortality was significantly lower in the EVAR group (adjusted OR= 0.34 [0.20-0.59]). The adjusted all-cause long-term mortality was similar in both groups (OR= 0.95 [0.81-1.05]). After adjustment for significant confounders, rates of imaging studies and both urgent and vascular readmissions were statistically higher in the EVAR group. However, the EVAR group had significantly shorter length of stay for the index hospitalization, all subsequent hospitalizations, and the intensive care unit. Discharge to a nursing home or other chronic care facility after the index procedure was also lower in the EVAR group (OR= 0.55 [0.41-0.74]). The durability of the repair of EVAR vs. open techniques as indicated by the rate of repeat interventions following the index procedure for EVAR (OR= 1.3 [0.98-1.75]) did not reach statistical significance.

Conclusion: After adjusting for pre-operative risk factors, there was no difference in long-term mortality between EVAR and open repair in Ontario. The significantly lower 30-day mortality rate in EVAR patients was not sustained over longer-term follow-up. Although the utilization of imaging studies and

hospitalizations was significantly higher in the EVAR group, patients undergoing open repair spent more days in hospital (including readmissions), more time in ICU, and were more likely discharged to a chronic care facility.

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1.0 INTRODUCTION

An abdominal aortic aneurysm (AAA) is a dilatation of the aorta of more than 50% of its original diameter. Since the average diameter of an aorta is 2 cm, a diameter of 3 cm is generally considered aneurysmal. Most AAAs result from a poorly understood degenerative process that occurs in the aortic wall. The primary clinical significance of AAA is rupture with a case-fatality rate of approximately 75%. Rupture risk is strongly associated with the maximum aneurysm diameter with annual risks of 1%, 11% and 25% for AAAs with diameters of 4-4.9 cm, 5-5.9 cm, and greater than 6 cm, respectively.^{1,2}

Prophylactic open surgical repair is standard of care treatment for AAAs. This requires a large incision in the abdomen, clamping the aorta above and below the aneurysm, and insertion of a synthetic graft in place of the aneurysmal aorta. Since the operation is associated with significant morbidity and mortality, surgery is reserved for patients with a critically large aneurysm. The UK Small Aneurysm Trial³ demonstrated that patients of average surgical risk having aneurysms smaller than 5.5 cm do not benefit from surgery since the surgical risk – an operative mortality of 5.8% in this study - exceeds rupture risk of the AAA.

In 1991, Parodi et al. introduced a less invasive procedure called the transfemoral EndoVascular Aneurysm Repair (EVAR). EVAR involves the passage of a stent graft through small incisions in both femoral arteries using guidewires and catheters.⁴ Since its introduction, EVAR has seen a constant evolution in devices and expertise.

Intuitively, EVAR was a less invasive method to repair AAAs. As such, EVAR was originally reserved for high-risk patients with AAAs who would not benefit from open surgical repair. Eventually, popularity for this less invasive method grew and restrictions to a high-risk population disappeared. This led to rapid and wide-scale implementation. Eventually, systematic reviews of non-randomized trials and two randomized controlled trials of non-high risk patients confirmed that EVAR was associated with significant reductions in operative mortality, intra-operative blood loss, and hospital length of stay compared to open repair.^{5 6 7}

However, enthusiasm for EVAR has been tempered by a better understanding of its long-term durability. Re-intervention rates as high as 35% at 3 years have been reported in long-term follow-up studies and have necessitated regular surveillance with post-operative imaging studies.^{8 9 10} In addition, the effect of EVAR on long-term protection from subsequent AAA rupture and death is unknown.

Long-term results of studies comparing EVAR and open repair have been inconsistent and difficult to interpret.^{9 11 12 13 14 15 16 17 18} The non-randomized controlled trials are either outdated, involve only a single institution, are poorly powered with small sample sizes, or do not properly control for patient risk status. Recently, the mid-term results from two ongoing randomized controlled trials comparing EVAR with open repair have become available.^{19 20} These studies show that the initial operative survival advantage following EVAR seen in both trials is not sustained (Table1). These studies also show that the increased

number of deaths in the EVAR group during the early follow-up period is not related to the endovascular repair but is likely due to patient co-morbidity. Although EVAR has a higher re-intervention rate, this does not appear to increase mortality.²¹ It is possible that the late mortalities seen in the EVAR group were higher risk patients - who would have experienced a perioperative death with open repair - succumbing to competing risks in the months following EVAR.

Several studies have compared the costs of EVAR and open repair. Most of the American reports have suggested that in-hospital costs are greater with EVAR than with open repair.^{22 23} One Canadian study of 38 patients revealed a cost of \$14 967 for EVAR vs. \$4 823 for open repair over a 2-14 month time-horizon.²⁴ However, this study was limited by its single institution experience, small sample size, short follow-up, and lack of adjustment for risk status.

Despite these results, EVAR utilization has continued to increase. This may be due to a perceived limited generalizability of the randomized trials because of their highly selected patient population or the perceived improvement in EVAR technology seen since the studies were conducted. In addition, patients may be more willing to accept the reported higher re-intervention rate associated with EVAR in an effort to avoid the higher risk of perioperative morbidity and mortality associated with the open procedure.

Several population based studies comparing EVAR and open repair of AAAs demonstrated significant reductions in operative mortality with the former.

^{25 26 27 28 29} Only 2 of these studies have compared long-term outcomes of EVAR and open-repair of AAA using administrative databases (Table 2). Bush *et. al.* found decreased long-term mortality with EVAR but their study was limited to male patients in the Veterans Administration system of the United States and had only 1 year follow-up.³⁰ Schermerhorn *et. al.* showed no difference in long-term mortality between patient groups in their large database study. However, their study was limited to Medicare patients exceeding 67 years of age.³¹ Neither study evaluated the quality of the procedural codes used to identify cases in the administrative databases. To date, no Canadian study has compared long-term results of EVAR and open repair..

Generalizable, population-based data that compare outcomes of EVAR and open AAA repair is lacking. Although EVAR has previously been reserved for high-risk populations, its use is continually being liberalized to younger and lower risk patients. It is, therefore, important to acquire more information to properly inform our patients of the long-term durability of EVAR, and be aware of the burden it may be placing on healthcare resources.

This study will examine population-based outcomes for EVAR and open repair of all elective AAA repairs in Ontario between 2002 and 2007. In addition to short and long-term mortality outcomes, we will analyze postoperative resource utilization.

2.0 METHODS

2.1 Study Overview

This is a retrospective cohort study using administrative databases of all patients who underwent elective surgical repair of an abdominal aortic aneurysm (AAA) in Ontario between 1 April 2002 and 31 March 2007. All surgeries used either conventional open repair or endovascular exclusion by a stent graft (EVAR).

All study data were obtained from several Ontario databases. These databases included CIHI-Discharge Abstract Database, the Ontario Diabetes Database, the Registered Persons Database, the Ontario Myocardial Infarction Database, the Ontario Health Insurance Plan database, and the Ontario Drug Benefits Database. These databases were linked to each other by a patient identifier number (the "IKN") that was common to each database.

2.2 Datasets used in the study

2.2.1 Canadian Institute for Health Information Discharge Abstract Database (CIHI-DAD).

The CIHI-DAD is a database including information on all acute care, rehabilitation, chronic, and day surgery institutions in Ontario. Each observation (or row) in the database represents one admission. Hospitalization data has been collected in Ontario since 1963 but data are only available for analysis beginning fiscal 1979-1980. In addition to demographic information about each patient (including gender and date of birth) and admission information (including

hospital number, admission urgency, admission and discharge dates, and disposition), the main data elements in the CIHI-DAD include twenty five diagnoses and twenty five procedures. Diagnoses are coded using the International Statistical Classification of Diseases and Related Health Problems (ICD) and procedures are coded using the Canadian Classification of Health Interventions (CCI).

After each patient is discharged from hospital, a Health Records Analyst (HRA) at the hospital reviews the medical record to identify information required to complete the hospitalization abstract. One abstract is completed for each admission to the hospital. The abstract must be completed according to the instructions outlined in the CIHI Abstracting Manual. The medical records coder assigns ICD-10-CA or CCI codes to each diagnosis or procedure identified in the medical record, respectively. All HRAs are graduates of a two year college program, must pass a coding certification exam, and attend biannual workshops given by the CIHI to help maintain coding acumen. In most institutions, coding is done using computer software (e.g. Med2020 Encoder, v. 6.30) and is usually completed within the first 7 days after the patient is discharged from hospital.

Hospitals forward completed records to CIHI in one month batches after (almost) all discharges for a given month are processed. There is usually a 3 or 4 month lag time between the end of the month and the time that CIHI receives the data. The data sets are available from CIHI by fiscal year. A typical year usually contains around 1.4 million records in Ontario. CIHI supplies the year-to-

date (current) file to the Ministry of Health, who decides when the fiscal year is to be closed and the master and standard fiscal files are created. This generally occurs around September of each year.

For this study, the variables obtained from the DAD include: a) the ICES key number (IKN) identifier; b) diagnostic fields to capture: all non-ruptured aneurysms; and co-morbidities based on the Charlson Co-morbidity Index (Appendix 3); c) procedural fields to capture operative procedures and re-intervention procedures; d) length of stay in hospital and intensive care units; and e) discharge disposition.

2.2.2 Registered Persons Database (RPDB)

The RPDB contains basic demographic information on all Ontarians who have registered with OHIP and have obtained a health card. Each person is assigned a unique and randomly generated 10 digit Health Number which is kept for his or her lifetime. The main elements contained in the database include: year of birth; gender; postal code of residence; date of last contact with a physician; and date of death. Information on deaths is collected by the Office of the Registrar General (ORG) of Ontario after editing by Statistics Canada. The Provincial Vital Statistics Act requires registration of all births, and deaths.

The ORG obtains information about all deaths from death certificates which are completed by physicians. All deaths in Ontario are registered in the Office of the Division Registrar within which the death occurs. A Statement of Death (Form 15) and a Medical Certificate of Death (Form 16) must be filed with a division registrar before a Burial Permit can be issued. The Registrar General

submits abstracts of death registration forms to Statistics Canada, where edit routines are applied to ensure data quality and completeness. Due to legal reporting requirements, registration of deaths is virtually 100% complete. However, deaths of residents occurring outside of Canada may be missing. Other reasons for not having a death registered in the database include late registration of deaths, deaths of unidentified persons, and deaths among serving members of the military (which are not registered by provincial registrars).

The variables obtained from the RPDB for this study included: a) date of birth; b) gender; and c) date of death (if it had occurred). This was performed by linking the ICES key numbers (IKN) from the cohort database to the RPDB.

2.2.3. Ontario Health Insurance Plan (OHIP)

The OHIP database contains claims made to the Ontario Health Insurance Plan. OHIP claims are prepared by the physician and submitted electronically to the district Ministry of Health office. From there, they are sent to the Kingston Head Office for electronic processing. The patient's health insurance number is checked for validity and eligibility. Some quality control checks are done on the services claimed by comparing it to currently available data for that patient. Each row (or record) in the OHIP database represents a unique service billed by a physician. Main elements of the database include; the fee code (representing the service administered); the date the service was performed; the billing physician; his/her specialty code; and the diagnosis at the time the service was billed. The data cover all health care providers who bill OHIP including individual physicians, physician groups, medical laboratories, and out-of-province

providers. Claims from Workers' Compensation are excluded from the OHIP claims database, as is remuneration to physicians belonging to Alternate Funding Plans (AFPs). Although AFPs account for only 5% of total physician expenditures, their concentration in certain specialties or geographic areas could distort an analysis. Approximately 94% of Ontario MDs have a fee-for-service practice. Some of the AFPs use shadow billing (a record for the service which appears in the OHIP database, although the fee paid may be shown as \$0.00). Thus, the OHIP claims data document some of the services provided in AFPs. The database is updated monthly and is current.

The OHIP database was used in this study to identify all patients who had fee codes for dialysis treatments, in-patient and out-patient computed tomography scanning, out-patient magnetic resonance imaging, outpatient angiographic studies, and out-patient physician visits. This was performed by linking the ICES key numbers (IKN) from the cohort database to the OHIP database.

2.2.4 Ontario Drug Benefit Database (ODB)

The Ontario Drug Benefit (ODB) database contains claims for all prescription drugs received under the Ontario Drug Benefit program. The data is entered by the pharmacist at the time of dispensing and is instantaneously collected through the Health Network System (HNS) that links all drug dispensing agencies in Ontario to a central ministry electronic system. All people entered into the database must have a valid OHIP card number and fall into one of the

following categories: age 65 years or older; residents of long-term care facilities; or residents receiving social assistance or home care regardless of age.

Each row represents a single claim to ODB for a prescribed medication. The main elements of the database include: the patient's OHIP number; the prescribing physician; the dispensing date; the Drug Identification Number (DIN); the quantity, total amount paid, and professional fee; and the Pharmacologic-Therapeutic Classification Group (PCG). The database is updated monthly by a dedicated individual at ICES and is current as information is entered instantaneously at the time the drug is dispensed.

ODB was used in this study for the following purposes: a) to identify patients prescribed medications for chronic obstructive pulmonary disease, coronary artery disease, hypertension, dementia, and HIV, (Appendix 4); and b) determine the number of distinct medication groups dispensed to the patient in the year prior to surgery. This was performed by linking the ICES key numbers (IKN) from the cohort database to the ODB.

2.2.5 Ontario Diabetes Database (ODD)

The Ontario Diabetes Database (ODD) was developed and validated at ICES. It was created by linking hospital discharge abstracts from the CIHI-DAD, physicians' service claims information from the OHIP database, and demographic information from the RPDB. Using the CIHI-DAD, all patients who were admitted to a hospital with the diagnosis of diabetes mellitus (DM), whether or not it was the primary reason for the admission, were identified. For outpatient

services, OHIP records were used to identify physicians' service claims for which DM was the recorded diagnosis.

All patients with two physician service claims bearing the diagnosis of DM within a two-year period or one hospitalization with a diagnostic code for DM are classified as having DM and enter the database. Any record bearing the DM diagnostic code, but followed within 5 months by a physician service claim or hospital discharge record indicating an obstetrical visit were eliminated to exclude women with gestational diabetes from the database. This algorithm has been previously validated in published data.³² This database is updated regularly by a dedicated individual at ICES.

The ODD was used for this study to determine if patients were diabetic.

2.2.6 Ontario Myocardial Infarction Database

The Ontario Myocardial Infarction database (OMID) was created and is maintained by ICES. The database contains data on all patients who have sustained an acute myocardial infarction (AMI) based on a validated algorithm.³³ Patients discharged from an acute care hospital in Ontario with the most responsible diagnosis of an AMI are first identified in the CIHI-DAD. These data are linked to the OHIP and the RPDB databases using the ICES key numbers. CIHI-DAD abstracts are excluded if the admission was less than 3 days or if the patient was transferred from another institution in order to avoid duplication. Non-Ontario residents and patients who had an AMI while admitted to a non-cardiac surgical service are also excluded. This database is updated by a dedicated individual at ICES annually as soon as the latest fiscal CIHI database is available, and therefore is current for the available data.

The OMID was used in this study to determine which patients in the cohort had significant coronary artery disease prior to their operation.

2.3 Study Dataset Creation

2.3.1 Study Period

The study observation period went from 1 April 2002 to 31 March 2007. A start date of 2002 was used to coincide with the introduction of CCI to Ontario hospitals. This was required since codes for EVAR were unavailable prior to the introduction of CCI. An end date of March 2007 was used because data was unavailable after March 2007.

2.3.2 Inclusion Criteria

Ontario patients were included in the study if they underwent elective surgery to repair an abdominal aortic aneurysm either by open surgical technique or by placement of an endovascular stent graft (EVAR). Patients with ruptured AAAs were excluded because these patients are not representative of our target population since we wanted to measure the effectiveness of these 2 operative techniques for *prophylactic* treatment of AAA. Patients were also excluded if they had aneurysms in locations other than the infrarenal region (including thoracic aneurysms, isolated iliac aneurysms, and pseudoaneurysms). These cases were excluded because they represent a vastly different procedure from AAA repair and their mortality rates (either open or endovascular) are different from AAA repairs. Finally, the study excluded non-Ontarians who underwent surgical repair in an Ontario hospital since their follow-up period is not captured by the Ontario health databases used for the study.

All patients were identified and classified using a validated algorithm developed by our team.³⁴ With this algorithm, we first identified all hospitalizations in which patients were coded with CCI codes for either an open AAA repair or an EVAR in the CIHI-DAD (Appendix 1). All duplicate patient admissions were identified and we kept only the first admission to ensure that a particular patient appeared only once in the study.

Patients were classified in the open surgical group if they were coded with a diagnosis of non-ruptured AAA and had intervention codes for an open AAA

procedure. Patients were placed in the EVAR group if they were coded with a diagnosis of non-ruptured AAA and intervention codes for an EVAR (Appendix 1).

2.3.3 Study Outcomes

2.3.3.1 Primary Outcome

The primary outcome was time to all-cause death following either open AAA repair or EVAR. Patient deaths were identified by linking to RPDB. Time to all-cause death was calculated as the number of days between the index operation and death from any cause.

2.3.3.2 Secondary Outcomes

2.3.3.3 30-day mortality

Patients were considered positive for 30-day mortality if they died within 30 days of the index operation

2.3.3.4 Length of stay in hospital

Hospital length of stay was calculated as the difference between the admission date and the discharge date in the CIHI-DAD. This includes time spent in the intensive care unit, step-down-units, alternative level of care, and awaiting placement units in the same institution.

2.3.3.5 Length of stay in ICU

The variable “*scuhrs*” in the DAD records the number of hours a patient spent in a special care unit including the intensive care unit, recovery unit, or other monitored area in the hospital. These hours are not necessarily contiguous and were captured for the index admission only.

2.3.3.6 Discharge to long-term care facility

Patients’ discharge disposition is recorded in the CIHI-DAD under the variable “*INSTTTYP*”. Patients with values other than a discharge to the community were counted as being discharged to a long-term care facility. This included the following institutions: active treatment hospital; general rehabilitation hospital; chronic hospital; nursing home; psychiatric hospital; unclassified health institution; special rehabilitation hospital; and homes for aged.

2.3.3.6 Days in hospital per patient year

All admissions (including the index admission) were obtained from the CIHI-DAD for each patient. We determined the duration of each admission in days and summed them to calculate the number of days spent in hospital during the entire study period in each intervention group. This was divided by the total number of days of observation in each group and multiplied by 365 to calculate the “number of days in hospital per patient year” for each group.

2.3.3.7 Re-interventions per patient year

Procedures with certain vascular, endovascular, or interventional radiology CCI codes in the CIHI-DAD (Appendix 2) that had an intervention date beyond

the index surgery date were considered re-interventions. This total number of re-interventions for each patient group was divided by the total number of days of follow up for the entire group and multiplied by 365 to calculate the “number of re-interventions per patient-year”.

2.3.3.8 Outpatient doctor visits per patient year

This included any outpatient visit to a physician (including primary care or specialist in a clinic or emergency department) where the service date occurred after the index surgery date. This information was obtained from the OHIP database using patient IKNs, service dates (variable “*servdate*”), and any OHIP billing code beginning with ‘A’ (indicating an outpatient visit). The total number of visits for the entire group was then divided by the total days of follow up for the entire group and multiplied by 365 to obtain “number of outpatient doctor visits per patient-year”.

2.3.3.9 Imaging studies per patient year

Any abdominal magnetic resonance imaging (MRI), computed tomographic (CT) scan, or angiogram performed after the index surgery date was considered a post-operative imaging study. Using fee codes for these procedures in the OHIP database (Appendix 2), the number of in-patient and out-patient CT scans, and out-patient MRI and angiograms were determined. Using the CIHI-DAD and the CCI codes for abdominal angiogram (Appendix 2), we were able to obtain the number of in-patient angiograms. We unfortunately could not determine the number of in-patient MRIs since these are not remunerated through OHIP claims,

and are not assigned a CCI code as they are not considered interventions. The total number of imaging studies for the each group was divided by the total days of observation for the entire group and multiplied by 365 to obtain “number of imaging studies per patient-year”.

2.3.3.10 Urgent and vascular readmissions per patient year

Any urgent admission in the CIHI-DAD beyond the index admission was counted when calculating “urgent admissions per patient-year”. Any admission in the CIHI-DAD with a vascular diagnosis being the most responsible diagnosis (ICD-10-CA code beginning with ‘I7’) was considered a vascular readmission. The total number of urgent or vascular readmissions for the entire group was then divided by the total days of follow up within each group to calculate “urgent” or “vascular readmissions per patient-year”.

2.3.4 Controlling Variables

The list of controlling variables is primarily based on the Charlson Comorbidity Index (Appendix 3). This is a validated index for classifying comorbidities to predict short- and long-term mortality.³⁵ Deyo *et. al.* developed an algorithm using ICD-9 codes in administrative databases to define all 17 comorbidities in the Charlson Index.³⁶ This algorithm has been successfully revised by Quan *et. al.* using ICD-10 codes.³⁷ We calculated the Charlson score for each patient by applying this coding algorithm to all diagnostic codes from hospitalizations in the CIHI-DAD prior to the index surgery.

In addition, three additional variables were included to capture more data on patient risk status. These include 'previous laparotomy', 'total number of medications', and 'number of urgent admissions in the year prior to surgery'. Methods used to calculate these variables are presented in Appendix 3.

To further determine heart disease status for each patient, we linked to the OMID database and to ODB to identify nitrate prescriptions. Patients who were coded as having heart disease if they: had a diagnosis in the CIHI-DAD for heart disease based on the revised Charlson algorithm; were present in the OMID database; or if they were prescribed a nitrate prescription from the ODB (Ontario Drug Benefit) in the year prior to surgery.

To further determine each patient's diabetes status, we linked to the Ontario Diabetes Database (ODD). Patients who were coded as having diabetes if they were: coded with diabetes in the CIHI-DAD based on the revised Charlson algorithm; or if they were present in the ODD.

The ODB was also used to further determine co-morbidity status for pulmonary disease, hypertension, human immunodeficiency virus (HIV) infection, and dementia by determining if patients had been prescribed: inhaled steroids, β -agonists, cholinergic inhalers; antihypertensives; retrovirals; and cholinesterase inhibitors, respectively. Only prescriptions in the year prior to surgery were considered.

Finally to further specify co-morbidity status on renal failure, we linked to the OHIP database to identify all patients who had a fee code for dialysis in the year prior to surgery. These patients were classified as having renal disease.

2.4 Statistical Analysis

2.4.1 Baseline covariates

Baseline covariates were compared for patients undergoing EVAR and open repair using Chi-square Tests for categorical variables and Student T-tests for continuous variables.

2.4.2 Primary Outcome

The primary outcome was time to all-cause death following either open AAA repair or EVAR. Unadjusted survival estimates were calculated by Kaplan-Meier method and compared using the Log-Rank test.

Cox proportional hazard modeling was used for the adjusted survival analysis. As there is an inherent bias to the decision of performing EVAR or open repair in patients based on their pre-operative risk status, long-term mortality results may be more a reflection of the pre-operative risk status rather than the type of procedure performed.

To account for this confounding, propensity score modeling was used. The propensity score is defined as the patient's probability of treatment assignment (i.e. EVAR vs. open repair) conditional on their measured co-morbidities.³⁸ The propensity analysis identifies patients with similar probability

of receiving either EVAR or open repair on the basis of their identified pre-operative characteristics. The propensity scores were calculated using multivariable logistic regression with pre-operative patient factors as the independent (predictor) variables and the assignment to EVAR or open repair as the dependent (outcome) variable. Clinically important interaction terms were included in the model. Using this method, we created 5 strata of propensity scores based on propensity score quintiles. Each stratum was similar for propensity score, thus balancing the co-morbidities. (Appendix 6.5) Previous observed differences in proportions of co-morbidities in the univariate analysis were no longer statistically significant amongst the matched patients within each stratum. Stratum-specific Cox-models were then combined to obtain an overall treatment effect of repair method.

2.4.3 Secondary Outcomes

2.4.3.1 30-day mortality

For the univariate analysis, the proportion of patients experiencing a death within 30 days was compared in each group using a Fisher's exact test. In the multivariate analysis, a logistic regression model was created using the type of surgery and the propensity score as independent variables.

2.4.3.2 Length of stay in hospital

For the univariate analysis, the mean number of hospital days for the index hospitalization was compared in each group using the Student's t test, as this followed a normal distribution. In the multivariate analysis, a linear

regression model was created using the type of surgery and the propensity score as independent variables.

2.4.3.3 Length of stay in ICU

For the univariate analysis, the mean number of ICU days for the index hospitalization was compared in each group using the Student's t test, as this is relatively normally distributed. In the multivariate analysis, a linear regression model was created using the type of surgery and the propensity score as independent variables.

2.4.3.4 Discharge to long-term care facility

For the univariate analysis, the proportion of patients discharged to a long-term care facility was compared in each group using a Fisher's Exact test. In the multivariate analysis, a logistic regression model was created using the type of surgery and the propensity score as independent variables.

2.4.3.5 Days in hospital per patient year

The univariate analysis was performed using incident densities and the GENMOD procedure, where the only independent variable was the type of surgery performed. For the multivariate analysis, the GENMOD procedure and Poisson regression analysis was used with the addition of the propensity score as an independent variable.

2.4.3.6 Re-interventions per patient year

The univariate analysis was performed using incident densities and the GENMOD procedure, where the only independent variable was the type of surgery performed. For the multivariate analysis, the GENMOD procedure and Poisson regression analysis was used with the addition of the propensity score as an independent variable.

2.4.3.7 Outpatient doctor visits per patient year

The univariate analysis was performed using incident densities and the GENMOD procedure, where the only independent variable was the type of surgery performed. For the multivariate analysis, the GENMOD procedure and Poisson regression analysis was used with the addition of the propensity score as an independent variable.

2.4.3.8 Imaging studies per patient year

The univariate analysis was performed using incident densities and the GENMOD procedure, where the only independent variable was the type of surgery performed. For the multivariate analysis, the GENMOD procedure and Poisson regression analysis was used with the addition of the propensity score as an independent variable.

2.4.3.9 Urgent and vascular readmissions per patient year

The univariate analysis was performed using incident densities and the GENMOD procedure, where the only independent variable was the type of surgery performed. For the multivariate analysis, the GENMOD procedure and

Poisson regression analysis was used with the addition of the propensity score as an independent variable.

3.0 RESULTS

We identified 6461 patients in the CIHI-DAD who underwent either an open AAA repair (n=5573) or EVAR (n=888) surgery in Ontario between April 2002 and March 2007. The total number of procedures by fiscal year is displayed in Figure 1. EVARs accounted for 5% of AAA procedures performed in 2002 and 26% in 2007. Patient characteristics are compared in Table 3.

Overall, patients undergoing EVAR were significantly older and were more likely to have significant comorbidities including heart disease, hypertension, peripheral vascular disease, cerebrovascular disease, pulmonary disease, and diabetes.

3.1 Univariate Analysis

The 30-day post-operative mortality was 1.8% following EVAR and 3.4% following open AAA repair (relative risk, 0.53 (0.31-0.89)). With respect to resource utilization during the index hospitalization, patients undergoing EVAR had significantly shorter hospitalizations, intensive care unit stays, and were less likely to be discharged to a long-term care facility (Table 4). In contrast, following the index hospitalization, EVAR patients had higher rates for vascular re-interventions, outpatient doctor visits, imaging studies, and hospital readmissions following the initial procedure as compared to patients undergoing open AAA repair (Table 4).

Patient survival is presented in Figure 2. There was an early survival benefit for patients undergoing EVAR within the first 100 days of observation.

After this time, however, patients undergoing open AAA repair have a significantly better survival (Log Rank test $p=0.0001$).

3.2 Multivariate analysis

3.2.1 The Propensity Score

The propensity analysis measured the probability that a patient would undergo EVAR vs. open repair based on each of the pre-operative baseline factors listed in Table 1. The propensity score was calculated using multivariable logistic regression with the operative modality (i.e. EVAR vs. open repair) as the outcome variable and the pre-operative baseline factors, along with important interaction terms, as the predictor variables. The final propensity model had a c-statistic of 0.72.

Stratum-specific Cox-models were then combined to obtain an overall treatment effect of repair method. An additional stratified analysis was performed in which the propensity score was separated into five quintiles and with the unadjusted Cox model repeated within each quintile. It should be noted that the operative groups did not differ significantly for any of the pre-operative variables listed in Table 3 within each propensity quintile. This indicates that the propensity analysis effectively removed differences between operative groups by baseline risk factors.

3.2.2 Mortality Outcomes

Table 5 shows all-cause mortality for EVAR and open repair after adjusting for baseline risk factors. The Cox proportional hazard analysis

suggested no statistically significant difference in long-term mortality (adjusted HR=0.95, 95% CI 0.81-1.05). There was, however, a reduction in the risk of death in the first 30 days by almost 65% after operation following EVAR as compared to open repair.

3.3.3 Resource Utilization

The multivariate analysis found that patients undergoing EVAR had a significantly shorter length of stay during the index hospitalization with a decrease of more than half a week compared to open repair (Table 6). Patients undergoing EVAR also had a significantly reduced time in the intensive care unit (-2.0 days) and were significantly less likely to be discharged from the index hospitalization to a long-term care facility (adjusted odds ratio 0.55).

In distinction to the index hospitalization, after adjusting for potential confounders, EVAR patients had significantly more imaging studies, slightly higher outpatient physician visits, and more urgent or vascular readmissions (Table 7). There was also a trend towards more re-interventions in EVAR patients, but this was not significant. In contrast, open repair patients spent a significantly greater number of days in hospital for the entire follow-up period, including all readmissions.

Analyses of survival by propensity score quintile is presented in Table 8. This shows that all-cause mortality did not differ significantly between EVAR and open repair in any propensity score quintile. In addition, there was no identifiable trend in the hazard ratio across the quintiles. In contrast, this analysis showed

that the benefit of EVAR on 30-day mortality was prominent and significant for patients whose risk of EVAR was in the 2 quintiles with the greatest probability of receiving EVAR.

4.0 DISCUSSION

The cohort studied represents the total population of patients undergoing repair of non-ruptured infrarenal abdominal aortic aneurysms in the province of Ontario over a 5-year fiscal period, either by endovascular or open surgical techniques. After accounting for important co-morbidities, patients undergoing EVAR had lower 30-day mortality, a shorter ICU stay, and a shorter hospitalization for the index surgery admission compared to those undergoing open repair. The probability of being discharged to a chronic care facility was also lower for the EVAR group. Most importantly, long-term mortality during the 5-year study period did not differ between the EVAR and open repair groups.

During the follow-up period, EVAR patients underwent significantly more imaging studies. Although EVAR patients had an insignificantly increased risk of surgical re-interventions, the total number of days spent in hospital during the entire follow-up period, including all readmissions, still remained significantly lower in the EVAR group compared to the open repair group.

The data in this study are similar to those from the 2 randomized controlled trials and are the only other population-based study evaluating long-term mortality outcome following EVAR and open repair techniques. Other population based studies exist but are limited to one year or less of follow-up period.

The importance of level-one evidence from the randomized controlled trials (RCTs) cannot be over-emphasized. However, their results are not as

readily generalizable to the population undergoing repair of AAAs in North America. The RCTs required patient selection to identify those not only fit enough for an open repair but who also had aortic anatomy that was suitable for an EVAR. Unlike the RCTs, this study included patients of varying degrees of operative risk and anatomical conditions in which the surgeon theoretically decided which treatment was best suited for each individual patient.

The other population-based study looking at long-term mortality outcome was very large, with a total sample size of 22 830 matched pairs. However, it was a sample of a much larger population of Medicare beneficiaries, which excludes patients younger than 67 years of age, and those with potentially other sources of health insurance. In contrast, this study included patients of all ages undergoing elective AAA treatment in a universal health care system. Most importantly, this study classified patients into operative groups based on a validated coding algorithm that accurately assigned the surgical mode of aortic aneurysm treatment. This accuracy is essential to avoid biased results from observational data within administrative databases.

Some other results from this study need to be highlighted. First, although there has been a steady rise in EVAR use in Ontario, only 26% percent of patients undergoing AAA treatment underwent EVAR by the end of the study period. This is small compared to almost half of patients in some American centres during the same period of time.²⁷ Second, we noted a significant difference in the survival curves in the unadjusted analysis (Figure 2) as well as significantly higher proportions of baseline co-morbidities in patients selected for

EVAR (Table 3). This indicates that Ontario vascular surgeons were overall very conservative, reserving EVAR for the higher risk patients seen during the study period. Third, the adoption of minimally invasive surgical techniques is often accompanied by increased volume of procedures as a result of lower operative thresholds. This did not seem to be the case for EVAR during this study period in Ontario. The total number of patients treated for AAAs remained fairly stable on an annual basis. This suggests that the same size threshold for open repair was likely respected for EVAR. In addition, these data suggest that there has not been any perceivable rise in overall number of procedures due to previously unoperated patients now undergoing EVAR.

Although differences between EVAR and open repair in re-intervention rates did not reach statistical difference, a small trend favoured open repair (OR 1.3). This difference is much smaller than what was previously reported, possibly a result of improvements in the EVAR learning curve, endograft technology, and a higher threshold for re-interventions, such as in the case for type 2 endoleaks. This study was not able to distinguish between re-interventions that were a result of a complication or failure of the initial surgical procedure from those which were unrelated, leading to an overestimation of total number of re-interventions. There is no reason, however, to assume that there is any relative difference between open repair and EVAR.

Selection bias was minimized using propensity-score analysis. The propensity score is defined as the patient's probability of treatment assignment (e.g. EVAR) conditional on measured co-morbidities.³⁹ With this method, 5 strata

of propensity scores were created. Each stratum was homogenous in their propensity score and thus balancing the co-morbidities. Previous observed differences in the proportion of co-morbidities in the univariate analysis were no longer statistically significant amongst the matched patients within each stratum. Stratum-specific estimates were then combined to obtain an overall treatment effect. Although propensity score analysis does not eliminate bias from unobserved variables, our list of 20 covariates was extensive and based on a previously validated modification of the Charlson co-morbidity index. We therefore consider it unlikely that an unobserved variable could have significantly affected the results.

A limitation of our study is the use of administrative databases and the quality of coding. We developed a coding algorithm that enabled us to separate EVAR and open repair patients with over 95% accuracy. It is well known that inaccurate coding of co-morbidities exists, usually increasing type 1 error, making it less likely to find differences between 2 groups. If the coding errors are not random, this may result in an unpredictably biased conclusion. We minimized this problem in our analysis by developing and using a coding algorithm that accurately classified patients in the correct surgical treatment group.

Another limitation of our study was that it was not designed to capture the actual operative or post-operative costs of each procedure. This was avoided since these cost estimates vary significantly between countries, provinces and states, and even hospitals, and therefore have decreased generalizability of

results. We hope that administrators and policy makers can use this data in planning resource allocation for treatment of patients with AAAs.

This study demonstrated that, on a population-basis, patients undergoing EVAR have similar long-term survival compared to those undergoing open repair for non-ruptured AAAs. Although there is increased resource utilization for EVAR patients with respect to imaging studies and slightly higher re-interventions, there is significantly less bed occupancy in hospital (initially and for all subsequent hospitalizations), in ICU and in chronic care facilities.

5.0 List of Tables and Figures

Table 1. Results from the 2 randomized –controlled trials comparing EVAR and open AAA repair

| Trial | Study period | n | 30-day mortality outcome (EVAR vs. open) | Long-term mortality |
|--------------|---------------------|----------|---|--|
| DREAM trial | 2000-2003 | 351 | 30-day mortality of 1.7 % for EVAR vs 4.7 % for open repair (odds ratio = 0.35) | 2 yr cumulative survival similar for EVAR (89.7%) and open repair (89.6%) |
| EVAR-1 | 1999-2004 | 1082 | 30-day mortality of 4.6% for open repair vs. 1.2 % for EVAR (risk ratio= 0.26) | 4 yrs after randomization, mortality was similar in EVAR and open repair groups (hazard ratio= 0.90) |

Table 2. Summary of population-based studies comparing patient survival following endovascular aneurysm repair (EVAR) vs. open AAA repair

| Author | Study period | Database | Sample population | Adjustment for risk factors | Mortality results | Study Limitations |
|--------------------|--------------|----------------|-------------------|--------------------------------|---|---|
| Schermerhorn et al | 2001-2005 | Medicare | 22830 pairs | Propensity score matched pairs | No difference, based on Kaplan-Meier analysis | Did not include patients under the age of 67; Kaplan Meier survival analysis only; no economic evaluation; no assessment of coding quality used for case ascertainment |
| Bush et al | 2001-2003 | Veterans NSQIP | 1904 | Propensity score analysis | Improved 1 yr survival for EVAR group (OR 0.61) | Study limited to 1 year of observation; no validated comorbidity index; females not included; did not assess re-intervention rates; no economic evaluation; no assessment of coding quality used for case ascertainment |

Table 3: Comparison of patients undergoing elective open AAA repair and EVAR between April 2002 and March 2007

| Factor | EVAR (%) n= 888 | Open Repair (%) n=5573 | Relative risk – EVAR vs. Open (95% CI) | p-value |
|--|--------------------------------------|--------------------------------------|--|---------|
| Median age | 76.0 (70.0-81.0)* | 72.0 (66.0-77.0)* | - | <0.0001 |
| Male gender | 86.2 | 80.3 | 1.07 (1.04-1.10) | <0.0001 |
| Peripheral vascular disease | 49.1 | 32.3 | 1.52 (1.40-1.64) | <0.0001 |
| Cerebrovascular disease | 13.7 | 9.9 | 1.40 (1.15-1.68) | <0.0001 |
| Heart disease | 42.3 | 28.6 | 1.48 (1.28-1.69) | <0.0001 |
| Congestive heart failure | 13.0 | 6.7 | 1.93 (1.57-2.35) | <0.0001 |
| Pulmonary disease | 33.6 | 21.7 | 1.55 (1.39-1.72) | <0.0001 |
| Diabetes | 23.8 | 18.0 | 1.32 (1.16-1.51) | <0.0001 |
| Hypertension | 72.9 | 60.9 | 1.20 (1.14-1.25) | <0.0001 |
| End-stage renal disease | 6.1 | 3.1 | 1.95 (1.43-2.64) | <0.0001 |
| Cancer | 17.7 | 12.7 | 1.40 (1.19-1.64) | <0.0001 |
| Metastatic cancer | 2.7 | 1.1 | 2.43 (1.48-3.95) | <0.0001 |
| Dementia | 2.3 | 1.3 | 1.77 (1.05-2.95) | 0.03 |
| Liver Disease – mild | 1.8 | 1.2 | 1.48 (0.83-2.60) | 0.2 |
| - moderate to severe | 0.8 | 0.3 | 2.58 (0.98-6.58) | 0.06 |
| HIV | 0.1 | 0.05 | 2.09 (0.09-22.3) | 1.0 |
| Previous laparotomy | 1.2 | 0.6 | 1.97 (0.95-4.01) | 0.07 |
| Paraplegia | 2.4 | 1.2 | 2.00 (1.19-3.32) | <0.0001 |
| Median number of distinct drug prescriptions in year prior to surgery | 8.0 (4.0-12.0)* | 6.0 (1.0-10.0)* | - | <0.0001 |
| Median {Mean} number of urgent admissions to hospital in the year prior to surgery | 0.0 (0.0-0.0)* {0.41 (0.36-0.47)} | 0.0 (0.0-0.0)* {0.24 (0.22-0.26)} | - | <0.0001 |

* median values expressed with interquartile ranges

Table 4: Univariate analysis of 30-day mortality and resource utilization outcomes

| Outcome | EVAR | Open Repair | Relative Risk or Rate Ratio – EVAR vs. Open (95% CI) | p-value |
|---|----------------|-----------------|--|---------|
| 30-day mortality | 1.8% | 3.4% | 0.53 (0.31-0.89) | 0.01 |
| Median Length of Stay – index admission (days) | 5.0 (3.0-7.0)* | 8.0 (6.0-11.0)* | - | <0.0001 |
| Median ICU stay - index admission (days) | 1.0 (1.0-3.0)* | 3.0 (2.0-5.0)* | - | <0.0001 |
| Discharge from index admission to long-term care facility | 6.9% | 7.9% | 0.87 (0.67-1.14) | 0.33 |
| Long Term Outcomes per Patient Year | | | | |
| - Days in hospital | 8.5 | 10.3 | 0.81 (0.73-0.90) | <0.0001 |
| - Re-interventions | 0.07 | 0.05 | 1.32 (1.00-1.75) | 0.05 |
| - Outpatient doctor visits | 15.0 | 12.3 | 1.21 (1.14-1.30) | <0.0001 |
| - Imaging studies | 3.1 | 0.5 | 6.23 (5.60-6.92) | <0.0001 |
| - Urgent readmissions | 0.5 | 0.3 | 1.67 (1.45-1.93) | <0.0001 |
| - Vascular readmissions | 0.07 | 0.03 | 2.22 (1.49-3.32) | <0.0001 |

*median values expressed with inter-quartile ranges

Re-interventions: any procedure, either open or endovascular, on the abdominal aorta (and its major branches), pelvic, or lower extremity vessels, and abdominal wall repairs, performed after the index surgery. **Imaging studies:** in-patient and out-patient abdominal CT scans and angiography, and outpatient abdominal MRIs, after the index surgery. **Outpatient doctor visits:** all visits to any specialist or primary care physician in the emergency department or clinic, after the index surgery. **Urgent readmissions:** any readmission with the admission code 'urgent'. **Vascular readmissions:** any readmission with the most responsible diagnosis being a vascular diagnosis. **Days in Hospital:** The total number of days spent in hospital, including all readmissions, for the entire follow-up period.

Table 5. Multivariate analysis of mortality outcomes for EVAR and open AAA repair

| Mortality outcome | Adjusted Hazard Ratio [95% CIs] (EVAR vs. open repair) | p-value |
|-----------------------------|---|----------------|
| 30-day all-cause mortality | 0.34 [0.20-0.59] | <0.0001 |
| Overall all-cause mortality | 0.95 [0.81-1.05] | 0.61 |

Each analysis adjusted for likelihood of receiving each operative type using a propensity score analysis.

Table 6. Multivariate analysis of resource utilization during and disposition from index admission

| Outcome | Group Comparison EVAR vs. Open Repair (95% CI) | p-value |
|--|---|----------------|
| Length of stay | -5.75 days (-4.85 to -16.65) | <0.0001 |
| Length of stay in ICU | -2.0 days (-1.00 to -3.05) | 0.0002 |
| Discharge to long-term care facility (Relative Risk) | 0.55 (0.41-0.74) | <0.0001 |

Table 7. Multivariate analysis of resource utilization after index hospitalization

| Outcome (per Patient Year) | Rate ratio (EVAR vs. open repair) | p-value |
|---------------------------------------|--|----------------|
| Re-interventions | 1.31 (0.98-1.75) | 0.073 |
| Imaging studies | 5.48 (4.91-6.11) | <0.0001 |
| Outpatient doctor | 1.09 (1.02-1.16) | 0.01 |
| Urgent readmissions | 1.23 (1.07-1.43) | 0.004 |
| Vascular readmissions | 1.59 (1.04-2.42) | 0.03 |
| Days in hospital | 0.67 (0.61-0.74) | <0.0001 |

Re-interventions: any procedure, either open or endovascular, on the abdominal aorta (and its major branches), pelvic, or lower extremity vessels, and abdominal wall repairs, performed after the index surgery. **Imaging studies:** in-patient and out-patient abdominal CT scans and angiography, and outpatient abdominal MRIs, after the index surgery. **Outpatient doctor visits:** all visits to any specialist or primary care physician in the emergency department or clinic, after the index surgery. **Urgent readmissions:** any readmission with the admission code 'urgent'. **Vascular readmissions:** any readmission with the most responsible diagnosis being a vascular diagnosis. **Days in Hospital:** The total number of days spent in hospital, including all readmissions, for the entire follow-up period.

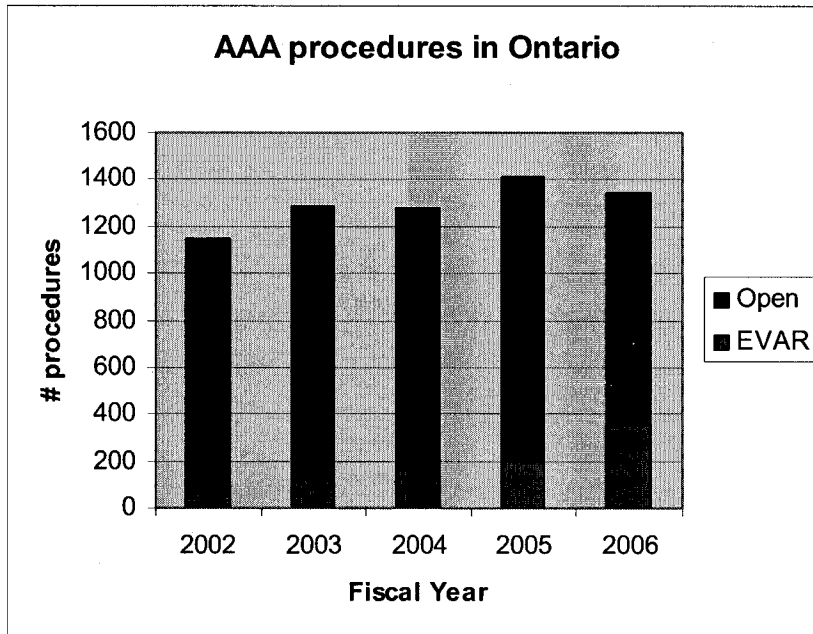
Table 8. Short and long-term mortality outcomes by propensity score quintile

| Outcome | Quintile 1 EVAR=73 Open=1219 | Quintile 2 EVAR=89 Open=1203 | Quintile 3 EVAR=130 Open=1163 | Quintile 4 EVAR=227 Open=1065 | Quintile 5 EVAR=369 Open=923 |
|---|------------------------------------|------------------------------------|-------------------------------------|-------------------------------------|------------------------------------|
| All-cause mortality hazard ratio (EVAR vs open repair) | 3.48 (p=0.22) | 0.61 (p=0.12) | 0.76 (p=0.27) | 1.21 (p=0.37) | 0.93 (p=0.57) |
| 30-day mortality odds ratio (EVAR vs. open) | Incalculable* | 0.87 (p=1.0) | 1.31 (p=0.70) | 0.11 (p=0.02) | 0.28 (p=0.001) |

Quintile 1 has the lowest probability of being assigned EVAR while quintile 5 has the highest probability of being assigned EVAR. The proportion of patients who received EVAR by quintile was: Q1= 8.2%, Q2= 10.0%, Q3=14.6%, Q4=25.6%, Q5=41.6%)

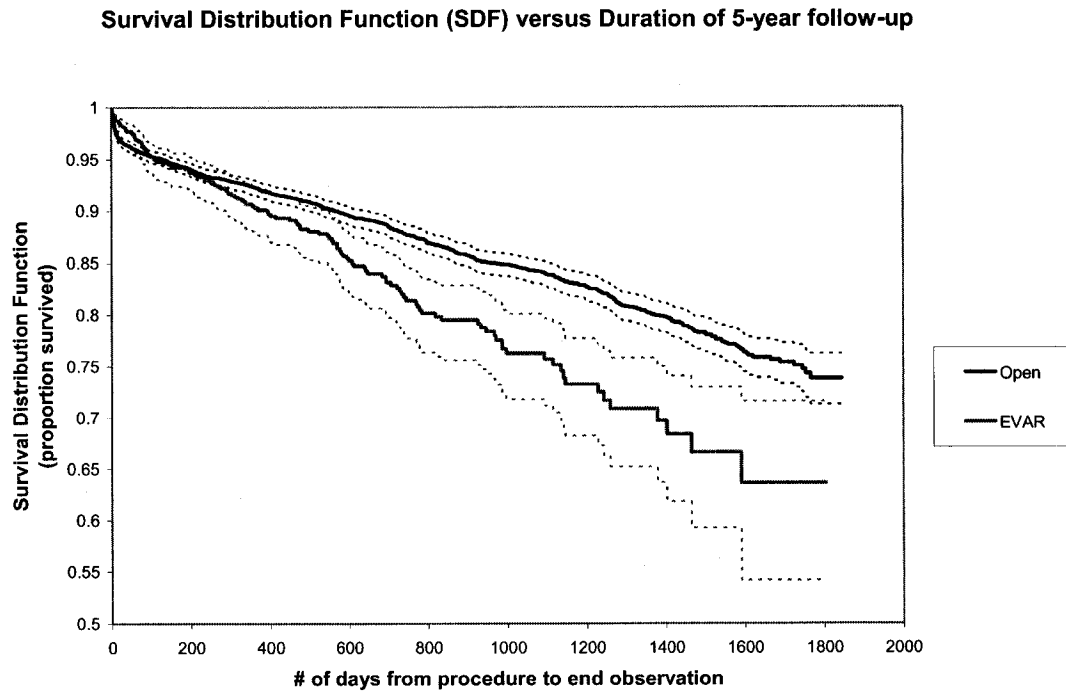
**Incalculable due to zero cell in EVAR group*

Figure 1. Total number of elective EVARs and open aortic aneurysm repairs by fiscal year



The horizontal axis presents the fiscal year of study. The vertical axis presents the total number of elective abdominal aortic aneurysm (AAA) repairs in Ontario. Open repairs are presented in blue; endovascular aneurysm repair (EVAR) is presented in red.

Figure 2. Survival distribution function (with 95% confidence intervals) of all patients undergoing EVAR and open repair procedures in Ontario from April 2002 to March 2007



6.0 APPENDICES

6.1 Appendix 1 - Coding algorithm

The ICD-10-CA and Canadian Classification of Health Interventions (CCI) coding systems were used to identify patients who underwent open repair versus EVAR techniques for non-ruptured AAAs. This was done using a validated coding algorithm which yields an overall procedure assignment accuracy of 97.3% [94.2-97.6] for EVAR and 95.9% [95.9-98.7] for open repair at our institution.³⁴

International Classification of Diseases and Related Health Problems (10th Revision)

The International Statistical Classification of Diseases and Related health problems- 10th revision (ICD-10) is an international standard for reporting clinical diagnoses developed by the World Health Organization. ICD-10-CA, an enhanced version of ICD-10 developed by the Canadian Institute for Health Information (CIHI), classifies diseases using an alpha-numeric code of 3-6 characters in length. Prior to the implementation of ICD-10-CA, a variety of medical classification standards were used in Canada for morbidity purposes. Two standards were in use at the national level for diagnosis classification: the *International Statistical Classification of Diseases, Injuries, and Causes of Death, Ninth Revision* (ICD-9) and the *ICD-9-Clinical Modification* (ICD-9-CM). This mixture of classification standards existed in Canada from 1979 and on the CIHI Discharge Abstract Database from 1987. As of April 1, 2002 this mix of

classifications was replaced with the new, single, national standards for diagnosis and procedure classification, the ICD-10-CA and the CCI.

The Canadian Classification of Health Interventions

The Canadian Classification of Health Interventions (CCI) is the new national standard for classifying health care procedures. CCI is the companion classification system to ICD-10-CA. CCI replaces the Canadian Classification of Diagnostic, Therapeutic and Surgical Procedures (CCP) and the intervention portion of ICD-9-CM in Canada. It was implemented in Ontario at the same time as ICD-10-CA, in April 2002. The CCI classifies a broad range of interventions, including therapeutic interventions, such as inpatient and day surgeries, and diagnostic interventions such as diagnostic imaging, tests, measurements, biopsies and explorations. It is very precise and has separate distinct codes for EVAR and open repair of AAAs. Prior to this, no distinction was made between the two approaches in the coding systems. As a result our study period starts from 2002.

Coding Algorithm

EVAR Group

Diagnostic code: I71.4

AND

Intervention codes: 1.KA.80.GQ-NRN or

1.KA.50.GS-BD or

1.KA.50.LA-BD or

1.KE.50.GQ-OA or

1.KE.51.GQ-GE

Open surgical group

Diagnostic code: I71.4

AND

Intervention codes: 1.KA.80.LA-XXN or

1.KA.76.NB-XXN or

1.KA.76.MZ-XXN or

*Any patient coded as an open repair but did not have a general anesthetic (INATEC1-20 codes 2, 3, 5, 6, 7, 8, 9, 10) will be considered to have had an EVAR.

6.2 Appendix 2 - Definitions of Outcome measures

1. Re-interventions per patient year: Procedures with certain vascular, endovascular or interventional radiology CCI codes in the CIHI-DAD with an intervention date beyond the index surgery date were considered re-interventions. These included any procedure, either open or endovascular, on the abdominal aorta (and its major branches), pelvic, or lower extremity vessels, and abdominal wall repairs. These were identified in the DAD using the following CCI code prefixes:

| Open or Endovascular Intervention | Code Prefix |
|--|--------------------|
| Aortic interventions | 1.KA.^.^ |
| Abdominal arteries interventions | 1.KE.^.^ |
| Pelvic vessels interventions | 1.KT.^.^ |
| Leg arteries interventions | 1.KG.^.^ |
| Axillofemoral bypass | 1.JM.MI-XXN |
| Abdominal wall hernia | 1.SY.80.^. |

The following are examples of re-intervention procedures that would be captured using the above codes:

- i. Endovascular aortic aneurysm repair
- ii. Open repair of abdominal aortic aneurysm
- iii. excision of aortic graft/stent
- iv. balloon angioplasty
- v. stent insertion into aorta or iliac arteries
- vi. embolization of any vessel
- vii. groin exploration

- viii. thrombectomy of vessel
- ix. embolectomy of vessel
- x. ligation of bleeding vessel
- xi. any re-operation on aorta, iliac vessel or femoral vessel
- xii. any operation for aortoduodenal fistula
- xiii. any operation for infected aortic graft
- xiv. any operation for occluded aortic graft
- xv. axillofemoral bypass
- xvi. femoro-femoral bypass
- xvii. Abdominal wall repair

2. Imaging studies per patient year: Any abdominal magnetic resonance imaging (MRI), computed tomographic (CT) scan or angiogram performed after the index surgery date was considered a post-operative imaging study. Using fee codes for these procedures in the OHIP database, the number of in-patient and out-patient CT scans, and out-patient MRI and angiograms were determined. Using the CIHI-DAD and the CCI codes for abdominal angiogram, we were able to obtain the number of in-patient angiograms. We unfortunately could not determine the number of in-patient MRIs since these are not remunerated through OHIP claims.

| Imaging study | OHIP Fee Code | CIHI-DAD code |
|--|------------------------------|----------------------|
| In-patient abdominal or pelvic CT scan | X409, X410, X126, X231, X233 | - |
| In-patient abdominal angiography | J021 | - |
| In-patient MRI | X451, X455, X461, X465 | - |

| | | |
|-------------------------------|------------------------------|---|
| Out-patient abdominal CT scan | X409, X410, X126, X231, X233 | - |
| Out-patient angiography | | 3.KC.10', 3.KT.10', 3.KE.10', 3.ID.10' |
| Out-patient MRI | n/a | n/a |

6.3 Appendix 3 - Definitions of variables based on the Charlson Comorbidity Index

1) age

- i) Age at time of the initial surgical procedure. Information was obtained from the RBDB.

2) sex

- i) Gender was determined based on information in the RPDB

3) peripheral vascular disease

- i) Any patient with diagnostic code for peripheral vascular disease in the CIHI DAD, including atherosclerosis of any vessel(s) in the body, excluding cerebral, coronary, and pulmonary. Also includes patients with previous aneurysm, dissection, and mesenteric ischemia.

4) coronary artery disease

- i) Any patient with diagnostic code for coronary artery disease in the CIHI DAD, including acute myocardial infarction, or old myocardial infarction (based on ECG or other tests)
- ii) Any patient previously entered into the OMID database.
- iii) Any patient in the ODB database with previous prescription of nitroglycerine in the year prior to index surgery.

5) heart failure

- i) Any patient with diagnostic code for heart failure in the CIHI DAD, including any cardiomyopathy, congestive heart failure, hypertensive heart disease or pericarditis.

6) chronic pulmonary disease

- i) Any patient with diagnostic code for chronic obstructive pulmonary disease in the CIHI DAD, including emphysema, chronic bronchitis, asthma, bronchiectasis, pneumoconiosis, and chronic respiratory conditions due to external agents.
- ii) Any patient with a prescription for a bronchodilator, inhaled steroids or cholinergic agent in the ODB database during the year prior to surgery.

7) diabetes

- i) Any patient with a diagnostic code for diabetes mellitus in the CIHI DAD prior to the index operation, including insulin dependent and non-insulin dependent diabetes mellitus, and excluding gestational diabetes mellitus.
- ii) Any patient in the ODD.

8) hypertension

- i) Any with a prescription for an antihypertensive agent in the ODB database during the year prior to surgery, including beta blockers, calcium channel blockers, ACE inhibitors, and combinations drugs.

9) previous cancer

- i) Any patient with diagnostic code for cancer in the CIHI DAD, including malignant neoplasms, malignant neoplasms of ill-defined, secondary and unspecified sites, or malignant neoplasms of lymphoid, haematopoietic and related tissue
- ii) Insitu neoplasms, and benign neoplasms are not included

10) metastatic cancer

- i) Any patient with diagnostic code for metastatic cancer in the CIHI DAD, including to lymph nodes or any secondary organ or site.

11) chronic renal failure

- i) Any patient with diagnostic code for chronic renal failure in the CIHI DAD
- ii) Any patient with billing codes for dialysis in the OHIP database during the year prior to surgery.

12) mild liver disease

- i) Any patient with diagnostic code for mild liver disease in the CIHI DAD, including chronic hepatitis, cirrhosis, and alcoholic liver disease

13) moderate or severe liver disease

- i) any patient with diagnostic code for major liver disease in the CIHI DAD, including chronic hepatic failure, hepatic venous occlusion, portal hypertension, hepatorenal syndrome, and varices

14) dementia

- i) Any patient with diagnostic code for dementia in the CIHI DAD, including dementia in Alzheimer's disease, vascular dementia, or dementia associated with other diseases.
- ii) Any patient with prescription for cholinesterase inhibitor in the ODB database during the year prior to surgery

15) connective tissue disease

- i) Any patient with diagnostic code for a connective tissue disorder in the CIHI DAD, including rheumatoid arthritis, systemic lupus erythematosus, systemic sclerosis, polymyalgia rheumatica, and giant cell arteritis.

16) peptic ulcer disease

- i) Any patient with diagnostic code for peptic ulcer disease in the CIHI DAD, including gastric, duodenal or jejunal ulceration.

17) paraplegia and hemiplegia

- i) Any patient with diagnostic code for paraplegia or hemiplegia in the CIHI DAD, including cerebral palsy or any paralytic syndrome.

18) HIV/AIDS

- i) Any patient previously with diagnostic code for HIV or AIDS in the CIHI DAD.
- ii) Any patient with a prescription for an antiretroviral drug in the ODB database during the year prior to surgery

19) previous laparotomy

- i) Any patient with diagnostic code for previous laparotomy incision in the CIHI DAD

20) number of medications

- i) The number of different prescriptions for each patient was calculated based on distinct drug identifier numbers (DINs) in the ODB database for each patient, during the year prior to surgery.

21) number of urgent admissions in the year prior to surgery

- i) the number of urgent or emergent admissions to a hospital during the year prior to surgery in the CIHI DAD was calculated for each patient.

6.4 Appendix 4 - Ontario Drug Benefits Database codes

1) Chronic pulmonary disease

- a. SUBCL code: 1.55E7
- b. SUBCLNAM: adrenergic bronchodilator, anticholinergics, inhaled corticosteroids, non-selective and selective beta adrenergic agonists

2) Dementia

- a. SUBCL code: 125050
- b. SUBCLNAM: cholinesterase inhibitors

3) Heart disease

- a. SUBCL code: 240412
- b. SUBCLNAM: coronary vasodilator

4) HIV

- a. SUBCL code: 8.18E6
- b. SUBCLNAM: nucleoside reverse transcriptase inhibitor, protease inhibitor, HIV infusion inhibitor, non-nucleoside reverse transcriptase inhibitor

6.5 Appendix 5- Balancing variables within strata using propensity scores

| q | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 | X12 | X13 | X14 | X15 | X16 | C17 | X18 | X19 | X20 | |
|---|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--|
| 1 | | | | | | | | | | | | | x | | | | | | | | |
| 2 | x | | | | | | | | | | | | | | | | | x | | | |
| 3 | | | | | | | | | | x | | | | | | x | | | | | |
| 4 | | | | | | | | | | | | | | | | | | | | | |
| 5 | x | | | | | | | | | | | | | | | | | | | | |

x= imbalanced covariates

q=quintile

6.6 Appendix 6 – SAS code

```

/*Apply GETCIHI Macro to create our cohort of all patients
who had a AAA dx, or EVAR or open AAA repair */

libname aaa '~/data/p619.00';
libname temp '~/data/p619.00/temp';
libname omid '/home/kinwah/data/phiat';

options mlogic mprint symbolgen mautosource sasautos=("/moh/macros");

%GETCIHI(start=20020401,
  end=20070331,
  source=all,
  out=aaa.step1_aug08,
  dx10code=("I714"),
  dxtype=alldx,
  incode=("1KA80LAXXN", "1KA80GQNRN", "1KA76MZXXN", "1KA76NBXXN",
    "1KA50GQOA", "1KA50GQBD", "1KA50GSBD", "1KE50GQOA", "1KE50GQBD",
    "1KE50GSBD"));

/* Create a dataset from dataset 1, where only patients with the diag for
non ruptured AAA (_dx_ =True) and one of the procedure codes(_pr_ =True)
{there is also a variable called "incode" which is only 10
characters long}, are kept)*/

data step2(drop=i);
  set aaa.step1_aug08;
  array _dx10code $ dx10code1-dx10code25;
  do i=1 to 25;
    if _dx10code(i)='I714' then output;
  end;
run;

data step2(drop=i);
  set step2;
  array _incode $ incode1-incode20;
  do i=1 to 20;
    if _incode(i) in ('1KA80LAXXN', '1KA80GQNRN', '1KA76MZXXN', '1KA76NBXXN',
      '1KA50GQOA', '1KA50GQBD', '1KA50GSBD', '1KE50GQOA', '1KE50GQBD',
      '1KE50GSBD') then output;
  end;
run;

/*Remove duplicate patient admissions, keeping only the first admission*/
proc sort data= step2 ;
  by IKN admdate;
run;

/* Keeping the 1st admission for each patient only */
data step3;
  set step2;
  by ikn;
  if first.ikn;
run;

/*Find the demographic data on all of the patients above by linking to the RPDB based
on IKN in the RPDB dataset, (ie age, bdate, pstlcode, sex, deathdate (this is a combination
CIHI data and MOH data)) using the GETDEMO macro IKNs do not need to be sorted ALTERNATIVELY
a MERGE statement BY IKN can be used*/
%getdemo(data=step3(drop=sex age),
  out=step4,
  getsex=T,
  agedate=admdate,
  getdeath=T,
  getdolc=T);

/*Tell SAS how to read the dates- unsure format Create new variable "DUR" which is duration of follow-up*

```

Create a new variable "DEATH" which reads dth variable as 1's and 0's- end of observation is 31mar2005*;/

```

data aaa.step45_aug08(drop=x);
  set step4;
  format indate1-indate20 indate admdate dthdate date9.;
  if dthdate = . or dthdate >'31mar2007'd then DEATH = 0;
  else DEATH = 1;
  label death = '1 - pt died during observation period';
  /*Determining the anaesthetic code and procedure date for the first of the interventions of interest*/
  array iindate{20} indate1-indate20;
  array iincode{20} $ incode1-incode20;
  array iinatec{20} $ inatec1-inatec20;
  do x = 1 to 20;
    if iincode{x} in ("1KA80LAXXN", "1KA80GQNRN", "1KA76MZXXN", "1KA76NBXXN", "1KE50GSBD",
                    "1KA50GQOA", "1KA50GQBD", "1KA50GSBD", "1KE50GQOA", "1KE50GQBD") then do;
      anaesthetic_code = iinatec{x};
      indate=iindate{x};
      x=20;
    end;
  end;
  label anaesthetic_code = "Anaesthetic code of 1st intervention of interest";
  if indate=. then indate=ddate;
  if death = 1 then dur = (dthdate-indate)+1;
  else dur = ('31mar2007'd - indate)+1;
  label dur = '# of days from procedure to end observation';

  /*Classify patients into their appropriate group based on procedure, and anesthesia type */

  evar = 0;
  open = 0;
  label evar = "1 - Pt had an evar AAA repair"
  open = "1 - Pt had an open AAA repair";
  do x = 1 to 20;
    if iincode{x} in ("1KA80LAXXN", "1KA76NBXXN", "1KA76MZXXN") AND anaesthetic_code='1' then open =1;
    if iincode{x} in ("1KA80LAXXN", "1KA76NBXXN", "1KA76MZXXN") AND anaesthetic_code='4' then open =1;
    if iincode{x} in ("1KA80LAXXN", "1KA76NBXXN", "1KA76MZXXN") AND anaesthetic_code='2' then evar =1;
    if iincode{x} in ("1KA80LAXXN", "1KA76NBXXN", "1KA76MZXXN") AND anaesthetic_code='3' then evar=1;
    if iincode{x} in ("1KA80LAXXN", "1KA76NBXXN", "1KA76MZXXN") AND anaesthetic_code='5' then evar=1;
    if iincode{x} in ("1KA80LAXXN", "1KA76NBXXN", "1KA76MZXXN") AND anaesthetic_code='6' then evar=1;
    if iincode{x} in ("1KA80LAXXN", "1KA76NBXXN", "1KA76MZXXN") AND anaesthetic_code='7' then evar=1;
    if iincode{x} in ("1KA80LAXXN", "1KA76NBXXN", "1KA76MZXXN") AND anaesthetic_code='8' then evar=1;
    if iincode{x} in ("1KA80LAXXN", "1KA76NBXXN", "1KA76MZXXN") AND anaesthetic_code='9' then evar=1;
    if iincode{x} in ("1KA80GQNRN", "1KE51GQGE", "1KE50GQOA", "1KA50GQOA", "1KA50GSBD",
                    "1KA50GQBD", "1KA50LABD", "1KE50LABD", "1KE50GSBD") then do;
      evar = 1;
      open = 0;
    end;
  end;
  if evar=1 then Operation=1;
  if open=1 then Operation=2;
  label operation= '1=EVAR and 2=open';
run;

data aaa.step45_aug08;
  set aaa.step45_aug08;
  where valikn='V';
run;

%codebook(data = aaa.step45);

/*get all the variables info on each patient.

/*Use getcihimacro to identify all the admissions for all patients in the cohort, including all diagnoses
(ICD9 and ICD10)going all the way back to 1991, and where ddate was before the surgery date (indate)*/

%getcih (source = all,
  start = 19910101,
  end = 20070331,

```

```

out = aaa.COHORTWITHALLCODES_aug08,
keep = ikn dxcode: dx10code: dxtype: prcode: incode: ddate,
cohort = aaa.step45_aug08(drop=ddate dx10code: dxtype: incode:),
cohortvar = ikn,
where = %str(ddate < indate)
)

data cohortwithallcodes;
set aaa.COHORTWITHALLCODES_aug08;
length fyear 3;
fyear=year(ddate)-(month(ddate) in (1,2,3));
if fyear < 2002 then do;
  dx_1=dxcode1;
  dx_2=dxcode2;
  dx_3=dxcode3;
  dx_4=dxcode4;
  dx_5=dxcode5;
  dx_6=dxcode6;
  dx_7=dxcode7;
  dx_8=dxcode8;
  dx_9=dxcode9;
  dx_10=dxcode10;
  dx_11=dxcode11;
  dx_12=dxcode12;
  dx_13=dxcode13;
  dx_14=dxcode14;
  dx_15=dxcode15;
  dx_16=dxcode16;
end;
else do;
  dx_1=dx10code1;
  dx_2=dx10code2;
  dx_3=dx10code3;
  dx_4=dx10code4;
  dx_5=dx10code5;
  dx_6=dx10code6;
  dx_7=dx10code7;
  dx_8=dx10code8;
  dx_9=dx10code9;
  dx_10=dx10code10;
  dx_11=dx10code11;
  dx_12=dx10code12;
  dx_13=dx10code13;
  dx_14=dx10code14;
  dx_15=dx10code15;
  dx_16=dx10code16;
  dx_17=dx10code17;
  dx_18=dx10code18;
  dx_19=dx10code19;
  dx_20=dx10code20;
  dx_21=dx10code21;
  dx_22=dx10code22;
  dx_23=dx10code23;
  dx_24=dx10code24;
  dx_25=dx10code25;
end;
run;

/*          Charlson Macro
OUTPUT:
          The macro will append 19 new variables to the original dataset.
          17 variables will indicate (1/0) if the person had a diagnosis in that category
          2 variables will summarize their comorbidity in a total score and an index.

DETAILS:
The CODES for the macro were taken from:Quan H, Sundararajan V, Halfon P. et. al. Coding algorithms for
defining comorbidities in ICD-9-CM and ICD-10 administrative data. MED CARE 2005;43:1130-1139.
The weights used to calculate the score were taken from: Schneeweiss S, Wang PH, Avor J, Glynn RJ. Improved
comorbidity adjustment for predicting mortality in medicare populations. HSR: Health Services Research 2003;
38: 1103-1120.

```

The base of this macro from taken without permission from
<http://www.umanitoba.ca/centres/mchp/concept/concept.frame.shtml>

```

*****/
%macro charlson;

data charlson;
  set COHORTWITHALLCODES;
  /**Myocardial Infarction**/
  %LET DIS1=MI;
  %LET DC1=%STR('I21','I22','I252','410','412');
  %LET LBL1=%STR(Myocardial Infarction);
  /**Congestive Heart Failure**/
  %LET DIS2=CHF;
  %LET DC2=%STR('I43','I50','I099','I110','I130','I132','I255','I420','I425','I426','I427','I428','I429','P290',
    '39891','40201','40211','40291','40401','40403','40411','40413','40491','40493','4254',
    '4255','4257','4258','4259','428');
  %LET LBL2=%STR(Congestive Heart Failure);
  /**Peripheral Vascular Disease**/
  %LET DIS3=PVD;
  %LET DC3=%STR('I70','I71','I731','I738','I739','I771','I790','I792','K551','K558','K559','Z958','Z959',
    '0930','4373','440','441','4431','4432','4438','4439','4471','5571','5579','V434');
  %LET LBL3=%STR(Peripheral Vascular Disease);
  /**Cerebrovascular Disease**/
  %LET DIS4=CEVD;
  %LET DC4=%STR('G45','G46','I60','I61','I62','I63','I64','I65','I66','I67','I68','I69','H340',
    '36234','430','431','432','433','434','435','436','437','438');
  %LET LBL4=%STR(Cerebrovascular Disease);
  /**Dementia**/
  %LET DIS5=DEM;
  %LET DC5=%STR('F00','F01','F02','F03','G30','F051','G311','290','2941','3312');
  %LET LBL5=%STR(Dementia);
  /**Chronic Pulmonary Disease*/
  %LET DIS6=CPD;
  %LET DC6=%STR('J40','J41','J42','J43','J44','J45','J46','J47','J60','J61','J62','J63','J64','J65','J66','J67',
    'I278','I279','J684','J701','J703','4168','4169','490','491','492','493','494','495','496','500','501',
    '502','503','504','505','5064','5081','5088');
  %LET LBL6=%STR(Chronic Pulmonary Disease);
  /**Connective Tissue Disease-Rheumatic Disease**/
  %LET DIS7=Rheum;
  %LET DC7=%STR('M05','M32','M33','M34','M06','M315','M351','M353','M360','4465','7100','7101','7102','7103',
    '7104','7140','7141','7142','7148','725');
  %LET LBL7=%STR(Rheumatic Disease);
  /**Peptic Ulcer Disease**/
  %LET DIS8=PUD;
  %LET DC8=%STR('K25','K26','K27','K28','531','532','533','534');
  %LET LBL8=%STR(Peptic Ulcer Disease);
  /**Mild Liver Disease **/
  %LET DIS9=MILDLD;
  %LET DC9=%STR('B18','K73','K74','K700','K701','K702','K703','K709',
    'K717','K713','K714','K715','K760','K762','K763','K764','K768','K769','Z944','07022','07023','07032','07033','07044','0705',
    '0706','0709','570','571','5733','5734','5738','5739','V427');
  %LET LBL9=%STR(Mild Liver Disease);
  /**Diabetes without complications**/
  %LET DIS10=DIAB_NC;
  %LET DC10=%STR('E100','E101','E106','E108','E109','E110','E111','E116','E118','E119',
    'E120','E121','E126','E128','E129',
    'E130','E131','E136','E138','E139','E140','E141','E146','E148','E149','2500','2501','2502','2503','2508','2509');
  %LET LBL10=%STR(Diabetes without complications);
  /**Diabetes with complications**/
  %LET DIS11=DIAB_C;
  %LET DC11=%STR('E102','E103','E104','E105','E107',
    'E112','E113','E114','E115','E117',
    'E122','E123','E124','E125','E127','E132','E133','E134','E135','E137','E142','E143','E144','E145',
    'E147','2504','2505','2506','2507');
  %LET LBL11=%STR(Diabetes with complications);
  /**Paraplegia and Hemiplegia**/
  %LET DIS12=PARA;
  %LET DC12=%STR('G81','G82','G041','G114','G801','G802',

```

```

'G830','G831','G832','G833','G834','G839',
'3341','342','343','3440','3441','3442','3443','3444','3445','3446','3449');
%LET LBL12=%STR(Paraplegia and Hemiplegia);
/**Renal Disease**/
%LET DIS13=RD;
%LET DC13=%STR('N18','N19','N052','N053','N054','N055','N056','N057',
'N250','I120','I131','N032','N033','N034','N035','N036','N037','Z490','Z491','Z492','Z940','Z992',
'40301','40311','40391','40402','40403','40412','40413','40492','40493','582','5830',
'5831','5832','5834','5836','5837','585','586','5880','V420','V451','V56');
%LET LBL13=%STR(Renal Disease);
/**Cancer**/
%LET DIS14=CANCER;
%LET DC14=%STR('C00','C01','C02','C03','C04','C05','C06','C07','C08','C09',
'C10','C11','C12','C13','C14','C15','C16','C17','C18','C19',
'C20','C21','C22','C23','C24','C25','C26',
'C30','C31','C32','C33','C34','C37','C38','C39',
'C40','C41','C43','C45','C46','C47','C48','C49',
'C50','C51','C52','C53','C54','C55','C56','C57','C58',
'C60','C61','C62','C63','C64','C65','C66','C67','C68','C69',
'C70','C71','C72','C73','C74','C75','C76',
'C81','C82','C83','C84','C85','C88',
'C90','C91','C92','C93','C94','C95','C96','C97','140','141','142','143','144',
'145','146','147','148','149','150','151','152','153','154','155','156','157',
'158','159','160','161','162','163','164','165','170','171','172','174','175',
'176','179','180','181','182','183','184','185','186','187','188','189','190',
'191','192','193','194','195','200','201','202','203','204','205','206','207','208','2386');
%LET LBL14=%STR(Cancer);
/**Moderate or Severe Liver Disease**/
%LET DIS15=MSLD;
%LET DC15=%STR('K704','K711','K721','K729','K765','K766','K767','I850','I859','I864','I982',
'4560','4561','4562','5722','5723','5724','5728');
%LET LBL15=%STR(Moderate or Severe Liver Disease);
/**Metastatic Carcinoma **/
%LET DIS16=METS;
%LET DC16=%STR('C77','C78','C79','C80','196','197','198','199');
%LET LBL16=%STR(Metastatic Carcinoma);
/**AIDS/HIV**/
%LET DIS17=HIV;
%LET DC17=%STR('B20','B21','B22','B24','042','043','044');
%LET LBL17=%STR(AIDS/HIV);

%do DI=1 %to 17; /*ICD9-E Charlson: 17 groups*/
  A&DI=0;
  %do DX=1 %to 25; /*DX_1 - DX_25*/
    B&DX=0;
    %do SN=3 %to 4;
      if substr(dx_&DX,1,&SN) in (&DC&DI)
        then C&SN=1;
      else C&SN=0;
      B&DX=B&DX +C&SN;
      drop C&SN;
    %end;
    A&DI=A&DI+B&DX;
    DROP B&DX;
  %end;
  if A&DI>0 then cat_&&DIS&DI=1;
  else cat_&&DIS&DI=0;
  label cat_&&DIS&DI = &&LBL&DI;
  DROP A&DI;
%end;

run;

proc sort data=charlson;
  by ikn;
run;

proc means noprint data=charlson nway;
  by ikn;
  var cat_;;

```

```

output out=_charl(keep=ikn cat_:) max=;
run;

data charlson;
  set charlson(keep=ikn);
  by ikn;
  if first.ikn;
run;

data charlson;
  length cat_ 3;
  merge charlson _charl;
  by ikn;
/* NOW calculating TOTAL COMORBIDITY SCORE using new WEIGHTS in TABLE 4 HSR 2003; 1103-1120 */
  total_comorbidity_score = 0;
  label total_comorbidity_score = "SUMmary score using weights from Schneiweiss";
  if cat_mi = 1 then total_comorbidity_score = total_comorbidity_score+1;
  if cat_pvd = 1 then total_comorbidity_score = total_comorbidity_score+1;
  if cat_cevd = 1 then total_comorbidity_score = total_comorbidity_score+1;
  if cat_diab_nc = 1 then total_comorbidity_score = total_comorbidity_score+1;
  if cat_para = 1 then total_comorbidity_score = total_comorbidity_score+1;
  if cat_chf = 1 then total_comorbidity_score = total_comorbidity_score+2;
  if cat_copd = 1 then total_comorbidity_score = total_comorbidity_score+2;
  if cat_mildld = 1 then total_comorbidity_score = total_comorbidity_score+2;
  if cat_diab_c = 1 then total_comorbidity_score = total_comorbidity_score+2;
  if cat_cancer = 1 then total_comorbidity_score = total_comorbidity_score+2;
  if cat_dem = 1 then total_comorbidity_score = total_comorbidity_score+3;
  if cat_rd = 1 then total_comorbidity_score = total_comorbidity_score+3;
  if cat_mslld = 1 then total_comorbidity_score = total_comorbidity_score+4;
  if cat_hiv = 1 then total_comorbidity_score = total_comorbidity_score+4;
  if cat_mets = 1 then total_comorbidity_score = total_comorbidity_score+6;
  if total_comorbidity_score = 0 then comorbidity_index = 0;
  else if 1<=total_comorbidity_score <=2 then comorbidity_index = 1;
  else if 3<=total_comorbidity_score <=4 then comorbidity_index = 2;
  else if 5<=total_comorbidity_score then comorbidity_index = 4;
  label comorbidity_index = "Comorbidity index stratifying score as per Charlson: 0,1-2,3-4,5+"
  total_comorbidity_score = "Summary score using weights";
  keep ikn cat_mi cat_pvd cat_cevd cat_diab_nc cat_para cat_chf
  cat_copd cat_mildld cat_diab_c cat_cancer cat_dem cat_rd cat_mslld
  cat_hiv cat_mets total_comorbidity_score comorbidity_index;
run;

%mend charlson;

%charlson;

/*Ischemic heart disease: if the patient was in OMID before the procedure, then CAD=1, else CAD=0
proc sql;
  create table temp.heartdisease as
  select a.ikn, b.frstdate
  from aaa.step45 as a, omid.new_omid as b
  where a.ikn = b.ikn and a.indate > b.frstdate;
quit;

data temp.heartdisease;
  set temp.heartdisease;
  cad=1;
run;
*/

/*diabetes: if the patient was in ODD prior to surgery then Diabetes=1, else diabetes=0*/
proc sql;
  create table temp.diabetes_aug08 as
  select a.ikn, b.diagdate
  from aaa.step45_aug08 as a, odd.odd2006 as b
  where a.ikn = b.ikn and a.indate > b.diagdate;
quit;

data temp.diabetes_aug08;
  set temp.diabetes_aug08;
  diabetes=1;

```

run;

/*identify all patients with CMG #258 (which previous laparotomy)
going all the way back to 1991, and where ddate was before the surgery date (indate)*/

%macro cih;

```
data cih_CMG258i;
set %do year=1990 %to 1991;
    cih.cih&year
%end;;
where ddate >= '01jan1991'd and cmg1992 = "258";
run;
```

```
data cih_CMG258ii(drop=i);
set %do year=1992 %to 2006;
    cih.cih&year
%end;;
array _cmg $ cmg1992-cmg2005;
do i=1 to dim(_cmg);
    if _cmg(i)='258' then output;
end;
run;
```

```
data cih_CMG258;
set cih_CMG258i cih_CMG258ii;
run;
```

%mend cih;

%cih;

```
proc sql;
create table temp.COHORTWITHCMG258_aug08 as
select a.ikn, b.ddate, a.indate
from aaa.step45_aug08 a, cih_CMG258 b
where a.ikn=b.ikn and b.ddate < a.indate;
quit;
```

```
proc sort data=temp.cohortwithcmg258_aug08 nodupkey;
by ikn;
run;
```

```
data temp.cohortwithcmg258_aug08;
set temp.cohortwithcmg258_aug08;
cmg258=1;
run;
```

/*using the ontario drug benefits (ODB) database, identify all patients who were prescribed a bronchodilator or inhaled steroid in the year prior to surgery (indate). The SUBCLNAM includes b-agonists, steroids and anticholinergics. The SUBCL is "1.55E7". They would have to have both the subclnam and the subcl to qualify.

This would indicate that they had COPD. Age65=F will give us drugs for patients younger AND older than 65. I'm assuming that servdate=date of prescription*/

```
%getodb (start=20001017,
end=20070331,
out=temp.COHORTCOPDMEDS_aug08,
keep=ikn din,
cohort=aaa.step45_aug08,
cohortvar=IKN,
cohort2=temp.din_copd_meds(keep=din drugname),
cohortvar2=din,
where=%str(servdate<indate and 0 < (indate-servdate) <= 365),
age65=F);
```

```
proc sort data=temp.cohortcopdmeds_aug08 nodupkey;
by ikn;
run;
```

```

data temp.cohortcopdmeds_aug08(keep=ikn drugname copd_meds);
set temp.cohortcopdmeds_aug08;
copd_meds=1;
run;

```

*/*Anyone who was on a cholinesterase inhibitor in the year prior to surgery, qualified as having DEMENTIA*/*

```

%getodb (start=20001017,
  end=20070331,
  out=temp.COHORTDEMENTIAMEDS_aug08,
  keep=ikn din,
  cohort=aaa.step45_aug08,
  cohortvar=IKN,
  cohort2=temp.din_dementia_meds(keep=din drugname),
  cohortvar2=din,
  where=%str(servdate<indate and 0 < (indate-servdate) <= 365),
  age65=F)
;

```

```

proc sort data=temp.cohortdementiameds_aug08 nodupkey;
by ikn;
run;

```

```

data temp.cohortdementiameds_aug08(keep=ikn drugname dementia_meds);
set temp.cohortdementiameds_aug08;
dementia_meds=1;
run;

```

*/*Anyone taking a coronary vasodilator in the year prior to surgery, qualified as having CAD.*

This allows us to capture outpatients. If we are doing this then maybe we should include angina patients/*

```

%getodb (start=20001017,
  end=20070331,
  out=temp.COHORTCADMEDS_aug08,
  keep=ikn DIN servdate,
  cohort=aaa.step45_aug08,
  cohortvar=IKN,
  cohort2=temp.din_CAD_meds(keep=din drugname),
  cohortvar2=din,
  where=%str(servdate<indate and 0 < (indate-servdate) <= 365),
  age65=F);

```

```

proc sort data=temp.cohortCADmeds_aug08 nodupkey;
by ikn;
run;

```

```

data temp.cohortCADmeds_aug08(keep=ikn din drugname servdate indate CAD_meds);
set temp.cohortCADmeds_aug08;
CAD_meds=1;
run;

```

*/*patients taking HIV meds in the past year, qualified as having HIV/AIDS*/*

```

%getodb (start=20001017,
  end=20070331,
  out=temp.COORTHIVMEDS_aug08,
  keep=ikn DIN servdate,
  cohort=aaa.step45_aug08,
  cohortvar=IKN,
  cohort2=temp.din_HIV_meds(keep=din subcl subclnam),
  cohortvar2=din,
  where=%str(servdate<indate and 0 < (indate-servdate) <= 365),
  age65=F)
;

```

```

proc sort data=temp.cohortHIVmeds_aug08 nodupkey;
by ikn;
run;

```

```

data temp.cohortHIVmeds_aug08(keep=ikn din subcl subclnam servdate indate HIV_meds);
set temp.cohortHIVmeds_aug08;
HIV_meds=1;
run;

```

```

/*using the ontario drug benefits (ODB) database, identify the number of different meds
prescribed to all patients in the cohort, within the last year prior to surgery (indate)*/
%getodb (start=20001017,
        end=20070331,
        out=temp.COHORTMEDS_aug08,
        keep=ikn din servdate,
        cohort=aaa.step45_aug08,
        cohortvar=IKN,
        where=%str(servdate<indate and 0 < (indate-servdate) <= 365),
        age65=F)
;
/*remove duplicate DINs*/
proc sort data=temp.COHORTMEDS_aug08(keep=ikn din servdate indate) nodupkey;
by ikn din;
run;
/*link the DINs with their corresponding drugname*/
proc sort data=temp.cohortmeds_aug08;
by din;
run;

proc sort data=din.druglist out=odb_druglist; /*this is the excel spreadsheet you sent me Azim*/
by DIN;
run;

data totalnumbermeds(keep=IKN prodname drugname din subcl subclnam);
merge temp.cohortmeds_aug08(in=a) odb_druglist;
by din;
if a;
run;

/*Now count the number of DISTINCT drugnames*/
proc sql;
create table distinctdrugnames as
select ikn, count(DISTINCT drugname) as number_drugs
from totalnumbermeds
group by ikn;
quit;

/*using the ontario drug benefits (ODB) database, identify patients on Bloodpressure meds in the year
prior to surgery indate.*/
%getodb (start=20001017,
        end=20070331,
        out=temp.COHORTHTNMEDS_aug08,
        keep=ikn DIN servdate,
        cohort=aaa.step45_aug08,
        cohortvar=IKN,
        cohort2=temp.din_hypertension_meds(keep=din subcl subclnam),
        cohortvar2=din,
        where=%str(servdate<indate and 0 < (indate-servdate) <= 365),
        age65=F)
;
proc sort data=temp.cohorthtnmeds_aug08 nodupkey;
by ikn;
run;

data temp.cohorthtnmeds_aug08(keep=ikn din subcl subclnam servdate indate htn_meds);
set temp.cohorthtnmeds_aug08;
htn_meds=1;
run;

/*Use OHIP macro to find all patients who had dialysis codes billed to OHIP by their physician in the year prior to surgery*/
%getohip (source=all,
        start=20001017,
        end=20070331,
        out=temp.COHORTOHIPDIALYSIS_aug08,
        keep=ikn feecode servdate,
        cohort=aaa.step45_aug08,
        where=%str(servdate<indate and 0 < (indate-servdate) <= 365 and

```

```

        (feecode in ('R849','G323','G326','G860','G862',
                    'G333','G863','S435'))
    )
;
proc sort data=temp.cohortohipdialysis_aug08 nodupkey;
by ikn;
run;

data temp.cohortohipdialysis_aug08(keep=ikn feecode servdate indate dialysis);
set temp.cohortohipdialysis_aug08;
dialysis=1;
run;

/*look in CIHI DAD, list the number of urgent or emergent admissions
(ADM CAT = U or E prior to 2002 or jus 'U' since 2002)
in the year prior to surgeryindate*/

%getcihi (source = all,
          start = 20001017,
          end = 20070331,
          out = temp.COHORTURGENTADMISSIONS_aug08,
          keep = ikn ddate admcat,
          cohort = aaa.step45_aug08(drop=ddate admcat),
          cohortvar = ikn,
          where = %str(ddate < indate and 0 < (indate-ddate) <= 365)
          );

proc sort data=temp.cohorturgentadmissions_aug08;
by ikn;
run;

data urgent1(keep=ikn admcat ddate indate urg_adm);
set temp.cohorturgentadmissions_aug08;
where admcat in ('U','E');
urg_adm=1;
/*if urg_adm=1 then output;
   else delete;*/
run;

/*this step should count the number of urgent admissions per patient (IKN) in the year prior to surgery*/
proc sql;
  create table urgent2 as
  select ikn, count(*) as number_urgentadmissions
  from urgent1
  group by ikn;
quit;

/*Link all the above newly created datasets to one master dataset which contains all the co-morbidity variables*/

proc sort data=charlson;
  by ikn;
run;

/*merge*/

/*CAD as per patients in OMID only
data master1;
merge charlson(in=in1) temp.heartdisease;
by ikn;
if in1;
if CAD=1 then OMID=1;
else OMID=0;
/*OMID = 1 or 0 */
run;*/

/*Diabetic patients with or without complications in CIHI or in ODD*/
data master2;
merge charlson(in=in1) temp.diabetes_aug08;
by ikn;
if in1;

```

```

    if ((diabetes=1) or (cat_diab_nc=1) or (cat_diab_c=1)) then alldiabetes=1;
    else alldiabetes=0;          /*alldiabetes = 1 or 0 */
run;

/*patients who had a previous laparotomy as per CIHI var CMG*/
data master3;
    merge master2(in=in1) temp.cohortwithcmg258_aug08;
    by ikn;
    if in1;
    if cmg258=1 then CMGlaparotomy=1;
    else CMGlaparotomy=0;      /*CMGlaparotomy = 1 or 0 */
run;

/*patients with COPD includes CIHI codes OR ODB codes for inhaled steroids, and B agonist/cholinergic puffers*/
data master4;
    merge master3(in=in1) temp.cohortCOPDmeds_aug08;
    by ikn;
    if in1;
    if (copd_meds=1) or (CAT_COPD=1) then COPD=1;
    else copd=0;               /*COPD= 1 or 0 */
run;

/*patients with dementia include CIHI codes OR ODB drugs for Cholinesterase inhibitors*/
data master5;
    merge master4(in=in1 drop=drugname) temp.cohortDEMENTIAmeds_aug08(drop=drugname);
    by ikn;
    if in1;
    if (dementia_meds=1) or (Cat_dem=1) then DEMENTIA=1;
    else DEMENTIA=0;          /*dementia = 1 or 0 */
run;

/*this variable combines all sources of CAD (CIHI, OMID and ODB for Nitrates)
data master6;
    merge master5(in=in1) temp.cohortCADmeds(drop=indate);
    by ikn;
    if in1;
    if (CAD_meds=1) or (CAT_MI=1) or (OMID=1) then Heart=1;
    else Heart=0;             /*heart = 1 or 0 */
/*run;*/

/*HIV patients have CIHI codes or ODB codes for retrovirals*/
data master7;
    merge master5(in=in1) temp.cohortHIVmeds_aug08(drop=indate servdate din);
    by ikn;
    if in1;
    if (HIV_meds=1) or (Cat_HIV=1) then HIV=1;
    else HIV=0;               /*HIV = 1 or 0 */
run;

/*number of distinct drugnames per patient in the year prior to surgery*/
data master8;
    merge master7(in=in1) distinctdrugnames;
    by ikn;
    if in1;
    if number_drugs=. then number_drugs=0;
run;                          /*number_drugs = 0 to infinity*/

/*HTN is based on whther they were on any antihypertensive in the year prior to surgery*/
data master9;
    merge master8(in=in1 drop=subcl subclnam) temp.cohortHTNmeds_aug08(drop=indate subcl subclnam);
    by ikn;
    if in1;
    if (HTN_meds=1) then HTN=1;
    else HTN=0;               /*HTN= 1 or 0 */
run;

/*This variable displays number of urgent or emergent admissions in the year prior to surgery*/
data master10;
    merge master9(in=in1) urgent2;
    by ikn;

```

```

    if in1;
    if number_urgentadmissions=. then number_urgentadmissions=0;
run;
/* number_urgentadmissions= 0 to infinity*/

/*2 new variables describing CRF. ESRDcghi includes only CIHI coded patients and allESRD
includes all patients from CIHI or OHIP codes for dialysis*/
data master11(drop=ddate indate servdate din);
merge master10(in=in1) temp.cohortOHIPdialysis_aug08(drop=indate servdate);
by ikn;
if in1;
if (dialysis=1) or (cat_rd=1) then allESRD=1;
else allESRD=0;
/*allESRD= 1 or 0 */
if cat_rd=1 then ESRDcghi=1;
else ESRDcghi=0;
/*ESRDcghi= 1 or 0 */
run;

data aaa.master_aug08(drop=i);
merge aaa.step45_aug08(in=in1 keep=ikn indate) master11;
by ikn;
if in1;

array ch cat_mi cat_pvd cat_cevd cat_diab_nc cat_para cat_chf cat_copd cat_mildld cat_diab_c
cat_cancer cat_dem cat_rd cat_msld cat_hiv cat_mets total_comorbidity_score comorbidity_index;
do j=1 to dim(ch);
if ch(j)=. then ch(j)= 0;
end;

if cad=. then cad=0;
/*if OMID=. then OMID=0;*/
if diabetes=. then diabetes=0;
if alldiabetes=. then alldiabetes=0;
if cmg258=. then cmg258=0;
if CMGlaparotomy=. then CMGlaparotomy=0;
if copd_meds=. then copd_meds=0;
if COPD=. then COPD=0;
if dementia_meds=. then dementia_meds=0;
if DEMENTIA=. then DEMENTIA=0;
if CAD_meds=. then CAD_meds=0;
/*if Heart=. then Heart=0;*/
if HIV_meds=. then HIV_meds=0;
if HIV=. then HIV=0;
if number_drugs=. then number_drugs=0;
if htn_meds=. then htn_meds=0;
if HTN=. then HTN=0;
if number_urgentadmissions=. then number_urgentadmissions=0;
if dialysis=. then dialysis=0;
if allESRD=. then allESRD=0;
if ESRDcghi=. then ESRDcghi=0;
run;

/* Get info. on variables */
%codebook(data=aaa.master,
var=cat_ total_comorbidity_score comorbidity_index
cad OMID diabetes alldiabetes cmg258 CMGlaparotomy
copd_meds COPD dementia_meds DEMENTIA CAD_meds Heart
HIV_meds HIV number_drugs htn_meds HTN
number_urgentadmissions dialysis allESRD ESRDcghi);

/*****OUTCOMES*****/

/*get outcome information on each patient. All the following variables are collected
post-operatively*/

/*****READMISSIONS*****/

```

```

/* get number of re-admissions following the original surgery*/

%getchi (source = all,
        start = 20011017,
        end = 20070331,
        redate=admdate,
        out = admits,
        keep = ikn admdate ddate admcat)

/* Include only non-elective admissions admcat in ('u'). Healthier patients are more
likely to have an elective procedure, therefore they should be excluded*/

proc sql;
    create table readmissions as
    select a.*, b.admdate as readmdate, b.ddate as redate, b.admcat as readmcat
    from aaa.step45_aug08 as a left join admits as b
    on a.ikn = b.ikn
    where (b.admdate NE a.admdate) and (b.admdate > a.indate) and b.admcat in ('U','E');
quit;

proc sort data=readmissions;
    by ikn;
run;

/*this step should count the number of readmissions per patient (IKN)post-surgery*/
proc sql;
    create table readmit1 as
    select ikn, count(*) as number_urgentreadmissions
    from readmissions
    group by ikn;
quit;

data aaa.stepmaster_aug08;
    merge aaa.step45_aug08(in=in1 keep=ikn indate dur) readmit1;
    by ikn;
    if in1;
    if number_urgentreadmissions=. then number_urgentreadmissions=0;
    urgentreadmissions= (number_urgentreadmissions/dur)*365;
    label urgentreadmissions=# of urgent readmissions / yr of followup;
run;
/*urgent*/

/* get all urgent readmissions that have a vascular diagnosis*/

%getchi (source = all,
        start = 20020401,
        end = 20070331,
        out = vascadmits,
        keep = ikn admdate ddate dx10code: admcat,
        dx10code= ('I7'),
        dxtype=alldx);
/* Include only non-elective admissions admcat in ('u'). Healthier patients are more
likely to have an elective procedure, therefore they should be excluded*/

proc sql;
    create table vascreadmissions as
    select a.*, b.admdate as readmdate, b.ddate as redate, b.admcat as readmcat
    from aaa.step45_aug08 as a left join vascadmits as b
    on a.ikn = b.ikn
    where (b.admdate NE a.admdate) and (b.admdate > a.indate) and b.admcat='U';
quit;

/*this step should count the number of readmissions per patient (IKN)post-surgery*/
proc sql;
    create table readmit2 as
    select ikn, count(*) as number_vascreadmissions
    from vascreadmissions
    group by ikn;
quit;

```

```

/*merge readmissions to master set*/
data aaa.stepmaster_aug08;
  merge aaa.stepmaster_aug08(in=in1) readmit2;
  by ikn;
  if in1;
  if number_vascreadmissions=. then number_vascreadmissions=0;
  vascurgentreadmissions= (number_vascreadmissions/dur)*365;
  label vascurgentreadmissions = '# of vasc urgent readmissions / yr of followup';
run;
/*vascur

```

```

/*****REINTERVENTIONS*****/

```

/*Count the number of all reinterventions done after the indate (of the original procedure) in the CIHI DAD. This includes in patient stuff only. Need to use OHIP for outpatient stuff.

Reinterventions were defined as follows:

| | |
|----------------------------------|-------------|
| Aortic interventions: | 1.KA.^.^ |
| Abdominal arteries interventions | 1.KE.^.^ |
| Pelvic vessels interventions | 1.KT.^.^ |
| Leg arteries interventions | 1.KG.^.^ |
| Axillofemoral bypass | 1.JM.MI-XXN |
| Abdominal wall hernia | 1.SY.80.^ |

**note: the variable 'indate' was created and describes the date of the original operation (AAA repair or EVAR).

Indate1-20 are

the dates of the reinterventions in the following code. The reinterventions had to be performed AFTER the indate of the original operation)

*/

```

%getcihi (source = all,
  start = 20020401,
  end = 20070331,
  out = interventions,
  keep = ikn admdate ddate incode,
  incode= ("1KA", "1KE", "1KG", "1KT", "1JM76MIXXN", "1SY80"));

```

```

proc sql;
  create table reinterventions as
  select a.*, b.admdate as readmdate, b.ddate as reddate
  from aaa.step45_aug08 as a left join interventions as b
  on a.ikn = b.ikn
  where (b.admdate NE a.admdate) and (b.admdate > a.indate);
quit;

```

```

proc sql;
  create table Reinterventions2 as
  select ikn, count(*) as number_reinterventions
  from Reinterventions
  group by ikn;
quit;

```

```

/*merge numbertotal_reinterventions to master set*/
data aaa.stepmaster_aug08;
  merge aaa.stepmaster_aug08(in=in1) Reinterventions2;
  by ikn;
  if in1;
  if number_reinterventions=. then number_reinterventions=0;
  reinterventions= (number_reinterventions/dur)*365;
  label reinterventions= '# of reinterventions/ year of follow-up';
run;
/*reinte

```

```

/*****RADIOLOGY*****/

```

/* Get number of Angiograms, MRIs, and CT scans performed post-operatively per ikn.

OHIP has info on all CTs, outpt MRI, and outpt ANGIO. CIHI has info on inpt ANGIO.
We are missing inpt MRI info unfortunately*/

```

%getohip (source=all,
  start=20011017,
  end=20070331,
  out=OHIPradiology,
  keep=ikn feecode servdate,
  cohort=aaa.step45_aug08,
  where=%str(servdate>indate and (feecode in ('X409','X410','X126','X231','X233',
    'X451','X455','X461','X465','J021'))))
;

proc sort data=OHIPradiology;
  by ikn;
run;

/*this step should count the number of all codes (number of CTs, MRIs, Angios) per patient (IKN) post-surgery*/
proc sql;
  create table OHIPradiology2 as
  select ikn, count(*) as number_imagings
  from OHIPradiology
  group by ikn;
quit;

/*now get in-patient Angiograms from CIHI*/

%getcihi (source = all,
  start = 20020401,
  end = 20070331,
  out = inpatientANGIO,
  keep = ikn admdate ddate incode:,
  incode=('3KC10', '3KT10', '3KE10', '3ID10')
  );

proc sql;
  create table inpatientANGIO as
  select a.*, b.admdate as readmdate, b.ddate as reddate
  from aaa.step45_aug08 as a left join inpatientANGIO as b
  on a.ikn = b.ikn
  where (b.admdate NE a.admdate) and (b.admdate > a.indate);
quit;

/*this step should count the number of inpatient ANGIOs per patient (IKN)post-surgery*/
proc sql;
  create table inpatientANGIO2 as
  select ikn, count(*) as number_inptANGIO
  from inpatientANGIO
  group by ikn;
quit;

data allimaging;
  merge inpatientANGIO2 OHIPradiology2;
  by ikn;
  if number_inptANGIO=. then number_inptANGIO=0;
  if number_imagings=. then number_imagings=0;
  total_images= number_imagings + number_inptANGIO;
run;

/*merge total_images to master set*/
data aaa.stepmaster_aug08;
  merge aaa.stepmaster_aug08(in=in1) allimaging;
  by ikn;
  if in1;
  if total_images=. then total_images=0;
  images=(total_images/dur)*365;
  label images= '# all imaging studies/ year of follow-up excluding inpatient MRI';/*images*/
run;

```

```

/*****OUTPATIENT OR EMERG VISITS BY A PHYSICIAN*****/

%getohip (source=all,
          start=20011017,
          end=20070331,
          out=OHIPvisits,
          keep=ikn feecode physnum servdate,
          cohort=aaa.step45_aug08,
          where=%str(servdate>indate)
          );

data OHIPvisits;
set OHIPvisits;
  if feecode in: ('A');
run;

proc sort data=OHIPvisits(keep=ikn physnum indate servdate) nodupkey;
  by ikn physnum servdate;
run;

/*this step should count the number of visits per patient (IKN) post-surgery*/
proc sql;
  create table OHIPvisits2 as
  select ikn, count(*) as number_visits
  from OHIPvisits
  group by ikn;
quit;

/*merge number_visits to master set*/
data aaa.stepmaster_aug08;
  merge aaa.stepmaster_aug08(in=in1) OHIPvisits2;
  by ikn;
  if in1;
  if number_visits=. then number_visits=0;
  visits= (number_visits/dur)*365;
  label visits= '# of outpat visits for anything / year of followup';/*visits*/
run;

/*****LENGTH OF STAY*****/

/*Calculate length of stay in days in Hospital (total), and in ICU
(note : only the first admission to ICU per hosp admission is counted)
*/
data los(keep=ikn totaldaysinhospital hoursinICU);
  set aaa.step45_aug08;
  totaldaysinhospital=los;
  *daysinICU=scudays1; /* variable 'scudays' not available in CIHI2002 + */
  hoursinICU=scuhr;
run;

/*merge LOS to master set*/
data aaa.stepmaster_aug08;
  merge aaa.stepmaster_aug08(in=in1) los;
  by ikn;
  if in1;
run;

/*Get (number of all days spent in hospital following surgery upto the censor date)
divided by
(the number of days followed upto censor date)*/

%getcghi (source = all,
          start = 20020401,
          end = 20070331,
          out = hospdays,
          keep = ikn admdate ddate los
          );

```

```

proc sql;
  create table hospdays as
  select a.*, b.admdate as readmdate, b.ddate as redate, b.los as ls
  from aaa.step45_aug08 as a left join hospdays as b
  on a.ikn = b.ikn
  where b.ddate >= a.indate;
quit;

proc sort data=hospdays nodupkey;
  by ikn readmdate;
run;

data hospdays;
set hospdays;
by ikn;
if first.ikn then ls=(ddate-indate)+1;
run;

/*need code to add up all length of stays (los's) per ikn- create a new variable called "daysinhospitalpostop"*/

proc sql;
  create table hospdays2 as
  select ikn, sum(ls) as daysinhospitalpostop
  from hospdays
  group by ikn;
quit;

/* "daysinhospitalpostop" divided by days followed to censoring (called 'dur')*/

data aaa.stepmaster_aug08;
merge aaa.stepmaster_aug08(in=in1) aaa.step45_aug08(keep=ikn death dthdate instttyp) hospdays2;
by ikn;
if in1;
if daysinhospitalpostop=. then daysinhospitalpostop=0;
inhospital = (daysinhospitalpostop/dur)*365;

label inhospital = '# days spent in hospital/ year of follow-up'; /*inhospital*/

if death=1 and (dthdate-indate < 31) then thirtydaydeath=1; /*30daydeath*/
else thirtydaydeath=0;

/****** DISCHARGE INSTITUTION - this is a mandatory code in CIHI *****/

if instttyp in ('1','2','3','4','5','6','7','9') then INSTITUTION=1;
else INSTITUTION= 0;

run;

/******ANALYSES OF DATA*****/

/******Univariate analysis*****/

/*Use fisher's exact test for categorical pre-op variables, and 2 sample Student T test for
continuous pre-op variables */

/*proc ttest data=aaa.step45;
  class OR;
  var age;
run;*/

data aaa.master_aug08;
merge aaa.master_aug08(in=in1) aaa.step45_aug08(keep=ikn sex operation);
by ikn;
if in1;

```

```

if operation=1 then OR=1;
else OR=0;
run;

proc freq data=aaa.master_aug08;
  tables (sex cat_pvd cat_cevd cat_para cat_chf cat_mildld cat_cancer dementia
    cat_msld HIV cat_mets /*omid heart*/ COPD alldiabetes HTN cmglaparotomy allesrd)*OR /
  chisq EXACT CL; /*columns: operation 1=EVAR, 2=Open*/
run;

proc ttest data=aaa.master_aug08;
  class OR;
  var number_drugs number_urgentadmissions; run;

/*****Univariate analysis of outcomes*****/

proc freq data=aaa.stepmaster_aug08;
  tables (thirtydaydeath)*OR / out=outcomedata chisq EXACT CL; /*columns: operation 1=EVAR, 2=Open*/
run;

/*Calculate total INCIDENCE density for each variable by type of operation 1= EVAR 2=OPEN */

proc sort data=aaa.stepmaster_aug08 out=by_OR_master;
by OR;
run;

/*this is the denominator*/
proc means data=by_OR_master sum noprint;
  by OR;
  var dur;
  output out=sum_dur sum=totaldur;
run;

/*these are the numerators*/

proc means data=by_OR_master sum noprint;
  by OR;
  var number_urgentreadmissions;
  output out = sum_urgadm sum= allurgadm;
run;

proc means data = by_OR_master sum noprint;
  by OR;
  var number_vascreadmissions;
  output out = sum_vascurgadm sum= allvascurgadm;
run;

proc means data = by_OR_master sum noprint;
  by OR;
  var number_reinterventions;
  output out = sum_reinterv sum= allreinterv;
run;

proc means data=by_OR_master sum noprint;
  by OR;
  var total_images;
  output out=sum_images sum=allimages;
run;

proc means data=by_OR_master sum noprint;
  by OR;
  var number_visits;
  output out=sum_visits sum=allvisits;
run;

proc means data=by_OR_master sum noprint;

```

```

by OR;
var daysinhospitalpostop;
output out=sum_inhosp sum=allinhosp;
run;

data sums;
merge sum_images(in=in1 drop=_type_) sum_visits(drop=_type__freq_)
      sum_inhosp(drop=_type__freq_) sum_dur(drop=_type__freq_)
      sum_urgadm(drop=_type__freq_) sum_vascurgadm(drop=_type__freq_)
      sum_reinterv(drop=_type__freq_);
by OR;
if in1;
run;

%tabfile(data=sums, file=~/bkup/p619.00/output/sums_aug08.txt)

/*data incidence;
set sums;
IDallinhosp=allinhosp/totaldur;
IDallvisits=allvisits/totaldur;
IDallimages=allimages/totaldur;
IDallreinterv=IDallreinterv/totaldur;
IDallvascureadm=allvascureadm/totaldur;
IDallurgadm=allurgadm/totaldur;
run;*/

data aaa.stepmaster_aug08;
set aaa.stepmaster_aug08;
ln_dur=log(dur);
run;

proc genmod data=aaa.stepmaster_aug08;
class OR;
model number_visits=OR / dist=poisson link=log offset=ln_dur scale=pearson type3;
run;

proc genmod data=aaa.stepmaster_aug08;
class OR;
model total_images=OR / dist=poisson link=log offset=ln_dur scale=pearson type3;
run;

proc genmod data=aaa.stepmaster_aug08;
class OR;
model daysinhospitalpostop=OR / dist=poisson link=log scale=pearson type3;
run;

proc genmod data=aaa.stepmaster_aug08;
class OR;
model number_urgentreadmissions=OR / dist=poisson link=log offset=ln_dur scale=pearson type3;
run;

proc genmod data=aaa.stepmaster_aug08;
class OR;
model number_vascreadmissions=OR / dist=poisson link=log offset=ln_dur scale=pearson type3;
run;

proc genmod data=aaa.stepmaster_aug08;
class OR;
model number_reinterventions=OR / dist=poisson link=log offset=ln_dur scale=pearson type3;
run;

proc ttest data= aaa.stepmaster_aug08;
class OR;
var urgentreadmissions vascurgentreadmissions reinterventions images visits inhospital;
run;

data aaa.stepmaster_aug08;
merge aaa.stepmaster_aug08(in=in1) aaa.step45_aug08(keep=ikn age)
      los(keep=ikn totaldaysinhospital hoursinICU);
by ikn;

```

```

    if in1;
run;

proc sort data=aaa.stepmaster_aug08 out=by_OR_master;
  by OR;
run;

proc means data=by_OR_master median clm;
  by OR;
  var totaldaysinhospital hoursinICU age;
run;

/*Describe the survival functions of EVAR and open repair using KM method, get a graph, and get 95% CI's
with outserv*/

proc lifetest data=aaa.stepmaster_aug08 plots=(s) cs=none graphics outsurv=a method=KM;
  time DUR*Death(0); /*the '0' refers to the value of patients who were right censored*/
  strata OR;
  symbol1 v=none color=black line=1;
  symbol2 v=none color=black line=2;
run;

%kmcurve(data=a,
  time=dur,
  strata=OR,
  out=kmout)

%tabfile(data=kmout,file=-/bkup/p619.00/output/kmout_aug08.txt)

/*****MULTIVARIATE ANALYSIS*****/

/*Propensity scores*/

/* Chisq test done above to see what differences exist between EVAR and open wrt comorbidities.*/

/*use stepwise logistic regression to create propensity score. PS=propensity score
OR =1 (EVAR) is the treatment indicator*/
/*
data aaa.master;
  set aaa.master(drop=OR age agegroup drugsdecile admissionsgroup PS rnks quintile);
  if operation=1 then OR=1 /*EVAR*/; /*
  if operation in (.,2) then OR=0 /*OPEN*/; /*
run;
*/
data aaa.master_aug08;
  merge aaa.master_aug08(in=in1) aaa.step45_aug08(keep=ikn age);
  by ikn;
  if in1;
run;

/*Classify continous variables into categories, then I can plot the coefficients to see if there
is a linear relationship with the odds of getting EVAR*/

data aaa.master_aug08;
  set aaa.master_aug08;
  if age < 40 then agegroup=1;
  if 40 <= age < 50 then agegroup=2;
  if 50 <= age < 60 then agegroup=3;
  if 60 <= age < 70 then agegroup=4;
  if 70 <= age < 80 then agegroup=5;
  if age >= 80 then agegroup=6;
run;
/*separate number_drugs into deciles*/
proc rank data= aaa.master_aug08 groups=10 out=aaa.master_aug08;
  ranks rnks;
  var number_drugs;
run;
data aaa.master_aug08;
  set aaa.master_aug08;

```

```

    drugsdecile =rnks + 1;
run;

data aaa.master_aug08;
  set aaa.master_aug08;
  if number_urgentadmissions =0 then admissionsgroup=1;
  if number_urgentadmissions =1 then admissionsgroup=2;
  if number_urgentadmissions >1 then admissionsgroup=3;
run;

/*the model for propensity scores creation*/

proc logistic data=aaa.master_aug08 descending;
  class sex agegroup(ref=first) drugsdecile(ref=first) admissionsgroup(ref=first);
  model OR= sex age*age cat_pvd cat_CEVD cat_para cat_CHF cat_Mildd cat_cancer
    dementia cat_MSLD HIV cat_METS COPD alldiabetes /*heart*/
    HTN cmglaparotomy drugsdecile admissionsgroup allESRD /*age*heart*/ age*sex
    /*COPD*heart alldiabetes*heart*/;
  selection=stepwise slentry=0.2 slstay=0.2;
  output out=preds pred=PS;
run;

/*separate into quintiles based on the estimated propensity score*/
proc rank data=preds(drop=rnks) groups=5 out=r;
  ranks rnks;
  var PS;
run;
data aaa.master_aug08;
  set r(drop=_level_);
  quintile=rnks + 1;
run;

/*look at breakdown of PS by treatment*/
proc freq data=aaa.master_aug08;
  tables quintile*OR;
run;
/*
need to confirm that propensity scores removed the initial biases (sensitivity analysis*/

proc sort data=aaa.master_aug08 out=by_quintile_master;
  by quintile;
run;

proc freq data=by_quintile_master;
  by quintile;
  tables (admissionsgroup drugsdecile agegroup sex cat_pvd cat_cevd cat_para cat_chf cat_mildd cat_cancer
  dementia
    cat_mslD HIV cat_mets /*heart*/ COPD alldiabetes HTN cmglaparotomy allesrd)*OR /
  chisq /*EXACT*/ CL; /*columns: operation 1=EVAR, 2=Open*/
run;

proc ttest data=by_quintile_master;
  class OR;
  by quintile;
  var number_drugs number_urgentadmissions age;
run;

/*do km curve for each quintile- Azim can you show me the top part of the KM graph like you did for me before?*/
data aaa.step45;
  merge aaa.step45(in=in1 drop=quintile) aaa.master(keep=ikn quintile);
  by ikn;
  if in1;
run;

proc sort data=aaa.step45 out=by_quintile_step45;
  by quintile;
run;

data by_quintile5;
  set by_quintile_step45;

```

```

where quintile=5;
run;

proc lifetest data=by_quintile5 plots=(s) graphics outsurv=a method=KM cs=none;
  by quintile;
  time DUR*Death(0); /*the '0' refers to the value of patients who were right censored*/
  strata OR;
  symbol1 v=none color=black line=1;
  symbol2 v=none color=black line=2;
run;

%kmcure(data=a,
  time=dur,
  strata=OR,
  out=kmout5)

%tabfile(data=kmout5,file=~\bkup\p619.00\output\kmout5.txt)*

/*****COX PROPORTIONAL HAZARDS*****/

data aaa.step45_aug08;
  merge aaa.step45_aug08(in=in1) aaa.master_aug08(keep=ikn quintile);
  by ikn;
  if in1;
run;
/*
proc sort data=aaa.step45 out=by_ps_step45;
  by ps;
run;

proc phreg data=by_ps_step45;
  model dur*death(0)=OR;
  strata ps;
run;

proc phreg data=by_ps_step45;
  model dur*death(0)=OR;
  by ps;
run;
*/

/*****sort by quintile now*****/

proc sort data=aaa.step45_aug08 out=by_quintile_step45;
  by quintile;
run;

proc phreg data=by_quintile_step45;
  model dur*death(0)=OR;
  strata quintile;
run;

proc phreg data=by_quintile_step45;
  model dur*death(0)=OR;
  by quintile;
run;

/*****Multivariate analysis for Incident densities*****/

proc genmod data=aaa.stepmaster_aug08;
  class OR;
  model number_visits=OR ps / dist=poisson link=log offset=ln_dur scale=pearson type3;
run;

proc genmod data=aaa.stepmaster_aug08;
  class OR;

```

```

model total_images=OR ps / dist=poisson link=log offset=ln_dur scale=pearson type3;
run;

proc genmod data=aaa.stepmaster_aug08;
class OR;
model daysinhospitalpostop=OR ps / dist=poisson link=log scale=pearson type3;
run;

proc genmod data=aaa.stepmaster_aug08;
class OR;
model number_urgentreadmissions=OR ps / dist=poisson link=log offset=ln_dur scale=pearson type3;
run;

proc genmod data=aaa.stepmaster_aug08;
class OR;
model number_vascreadmissions=OR ps / dist=poisson link=log offset=ln_dur scale=pearson type3;
run;

proc genmod data=aaa.stepmaster_aug08;
class OR;
model number_reinterventions=OR ps / dist=poisson link=log offset=ln_dur scale=pearson type3;
run;

/*****Multivariate analysis for 30-day death *****/

proc logistic data=aaa.stepmaster_aug08 descending;
class OR;
model thirtydaydeath= OR ps/
selection=stepwise slentry=0.2 slstay=0.2;
output out=preds pred=PS;
run;

/**** Sept 8th 2007*****/

*****Assess 30 day death rates for EVAR and open surgery by quintile
need 95% CLMs and p values*****/

proc sort data=aaa.stepmaster_aug08 out=by_quintile_step45;
by quintile;
run;

proc freq data=by_quintile_step45;
tables (thirtydaydeath)*OR / out=outcomedata chisq EXACT CL; /*columns: operation 1=EVAR, 2=Open*/
by quintile;
run;

proc logistic data=by_quintile_step45 descending;
class OR;
model thirtydaydeath= OR/
selection=stepwise slentry=0.2 slstay=0.2;
output out=preds pred=PS;
by quintile;
run;

/*****Multivariate analysis for Length of stay for EVAR and Open repair, (overall and by quintile)*****/

proc glm data= by_quintile_step45;
class OR;
model totaldaysinhospital = OR ps/ solution;
by quintile;
run;

/*****Multivariate analysis for Hours in ICU for EVAR and Open repair, (overall and by quintile)*****/

```

```

proc glm data= by_quintile_step45;
  class OR;
  model hoursinICU = OR ps/ solution;
  by quintile;
run;

```

```

/***** need the following for the univariate incident density comparisons
1. 95% CLMs for the incidence density value (eg allimages/sum_dur)
2. 95% CLMs and p values for the rate ratio (eg. incidence density for EVAR divided by incidence density for
open)

```

| OR | FREQ. | allimages | allvisits | allinhosp | sum_dur | allurgadm | allvascrgadm | allreinterv |
|----|-------|-----------|-----------|-----------|---------|-----------|--------------|-------------|
| . | 87 | 115 | 1849 | 1934 | 46021 | 61 | 9 | |
| 1 | 343 | 1434 | 6343 | 5316 | 137944 | 248 | 29 | |
| 2 | 3276 | 2415 | 60107 | 52265 | 1665456 | 1580 | 166 | 265 |

```

**/

```

```

/*****Univariate Incidence Density comparisons*****/

```

```

/*

```

```

data aaa.stepmaster;

```

```

set aaa.stepmaster;

```

```

ln_dur=log(dur);

```

```

run;

```

```

*/

```

```

proc genmod data=aaa.stepmaster_aug08;

```

```

  class OR(param=ref ref=last);

```

```

  model number_visits=OR / dist=poisson link=log offset=ln_dur scale=pearson type3;

```

```

  estimate 'RR evar/open' OR 1 / exp;

```

```

run;

```

```

proc genmod data=aaa.stepmaster_aug08;

```

```

  class OR(param=ref ref=last);

```

```

  model total_images=OR / dist=poisson link=log offset=ln_dur scale=pearson type3;

```

```

  estimate 'RR evar/open' OR 1 / exp;

```

```

run;

```

```

proc genmod data=aaa.stepmaster_aug08;

```

```

  class OR(param=ref ref=last);

```

```

  model daysinhospitalpostop=OR / dist=poisson link=log scale=pearson type3;

```

```

  estimate 'RR evar/open' OR 1 / exp;

```

```

run;

```

```

proc genmod data=aaa.stepmaster_aug08;

```

```

  class OR(param=ref ref=last);

```

```

  model number_urgentreadmissions=OR / dist=poisson link=log offset=ln_dur scale=pearson type3;

```

```

  estimate 'RR evar/open' OR 1 / exp;

```

```

run;

```

```

proc genmod data=aaa.stepmaster_aug08;

```

```

  class OR(param=ref ref=last);

```

```

  model number_vascreadmissions=OR / dist=poisson link=log offset=ln_dur scale=pearson type3;

```

```

  estimate 'RR evar/open' OR 1 / exp;

```

```

run;

```

```

proc genmod data=aaa.stepmaster_aug08;

```

```

  class OR(param=ref ref=last);

```

```

  model number_reinterventions=OR / dist=poisson link=log offset=ln_dur scale=pearson type3;

```

```

  estimate 'RR evar/open' OR 1 / exp;

```

```

run;

```

```

/***** December 10th, 2007*****/

```

/* I need 95% CI's for the Cox proportional Hazard ratios for the overall Hazard ratio and by quintile*/

```
data aaa.step45_aug08;
  merge aaa.step45_aug08(in=in1) aaa.master_aug08(keep=ikn ps);
  by ikn;
  if in1;
run;
```

```
proc sort data=aaa.step45_aug08 out=by_quintile_step45;
  by quintile;
run;
```

```
proc phreg data=by_quintile_step45;
  model dur*death(0)=OR;
  strata quintile;
  baseline out=base_overall upper=ucl lower=lcl;
```

```
run;
```

```
proc phreg data=by_quintile_step45;
  model dur*death(0)=OR;
  by quintile;
  baseline out=base_quintile upper=ucl lower=lcl;
run;
```

/* I need median and interquartile range for median length of stay (totaldaysinhospital), median hours in ICU (hoursinICU), median age (age), aswell as the absolute difference with interquartile ranges using Wilcoxon ranked sum test for EVAR vs open repair*/

```
proc sort data=aaa.stepmaster_aug08 out=by_OR_master;
  by OR;
run;
```

```
proc univariate data=by_OR_master;
  by OR;
  var totaldaysinhospital hoursinICU age;
run;
```

/* I need median and interquartile range for "number_drugs", and "number_urgentadmissions", aswell as the absolute difference with interquartile ranges using Wilcoxon ranked sum test for EVAR vs open repair*/

```
proc univariate data=aaa.master_aug08;
  class OR;
  var number_drugs number_urgentadmissions;
run;
```

/****** AUG 25th 2008 UNIVARIATE and MULTIVARIATE ANALYSIS INSTITUTION DISCHARGED *****/

```
proc freq data=aaa.stepmaster_aug08;
  tables (INSTITUTION)*OR / out=institutiondata chisq EXACT CL; /*columns: operation 1=EVAR, 2=Open*/
run;
```

```
proc logistic data=aaa.stepmaster_aug08 descending;
  class OR;
  model INSTITUTION= OR ps/
  selection=stepwise slentry=0.2 slstay=0.2;
  output out=preds pred=PS;
run;
```

```
/****** EVAR vs Open repair by fiscal year *****/
```

```
data aaa.step45_aug08;  
set aaa.step45_aug08;  
fyear=year(ddate)-(month(ddate) in (1,2,3));  
run;  
  
proc freq data=aaa.step45_aug08;  
  tables (fyear)*OR /  
  chisq /*EXACT*/ CL; /*columns: operation 1=EVAR, 2=Open*/  
run;
```

7.0 REFERENCES

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