ORIGINAL SCIENTIFIC ARTICLE

Management of IVC Injury: Repair or Ligation? A Propensity Score Matching Analysis Using the National Trauma Data Bank

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BACKGROUND: Ligation can be used as part of damage-control operations under critical conditions after IVC injury. Inferior vena cava ligation could potentially yield greater survival benefit compared with repair after injury. We hypothesized that ligation significantly improves outcomes compared with repair.

STUDY DESIGN: The National Trauma Data Bank dataset for 2007-2014 was reviewed. Eligible patients included those sustaining IVC injury who underwent surgical ligation or repair. Data on demographics, outcomes, and complications were collected. Comparative analysis of demographic characteristics, complications and outcomes were performed.

RESULTS: There were 4,865 patients identified in the National Trauma Data Bank with IVC injury. A total of 1,316 patients met inclusion criteria. Four hundred and forty-seven patients (34.0%) underwent ligation and 869 (66.0%) underwent repair. Before matching, the ligation group was sicker than the repair group and the in-hospital mortality was significantly higher in the ligation group (43.8% vs 36.2%; odds ratio [OR] 1.37; 95% CI 1.09 to 1.73). One to one propensity score matching generated 310 pairs. After propensity score matching, in-hospital mortality was similar (41.3% vs 39.0%; OR 1.10; 95% CI 0.80 to 1.52). However, IVC ligation was associated with significantly higher complication rates of extremity compartment syndrome (OR 5.23; 95% CI 1.50 to 18.24), pneumonia (OR 1.76; 95% CI 1.08 to 2.86), deep venous thrombosis (OR 2.83 95% CI 1.70 to 4.73), pulmonary embolism (OR 3.63; 95% CI 1.18 to 11.17), and longer hospital length of stay (17.0 days [interquartile range 1.0 to 35.0 days] vs 9.0 days [interquartile range 1.0 to 22.0 days]; p = 0.002).

CONCLUSIONS: Inferior vena cava ligation is not superior to repair in terms of decreasing mortality in patients with IVC injury, but it is associated with higher complication rates and hospital LOS. (J Am Coll Surg 2018;■:1−8. © 2018 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)

Inferior vena cava injury carries high mortality rates varying from 20% to 66%.[1-9] Approximately 30% to 50% of patients die before arriving at the hospital.[10,11] Therefore, immediate bleeding control to achieve hemostasis becomes critical if outcomes are to be improved. However, surgical management can be challenging due to difficulty in exposing the injury site in the retroperitoneum when associated with massive hemorrhage and hematoma.

Controversy still exists about the best surgical management for IVC injuries. Although primary repair is the preferred method, it might not always be possible. Compared with venous repair, which requires reconstructive techniques, ligation of IVC can be performed simply and quickly. Ligation is certainly preferable as part of damage-control operations in patients who are critically ill, coagulopathic, acidotic, and hypothermic.

The decision to use each method can be very difficult and surgeons tend to hesitate in ligating the IVC without first trying primary repair because of concerns related to the development of potential complications, such as lower-extremity swelling, acute compartment syndrome, and post-thrombotic syndrome. Although some studies

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Abbreviations and Acronyms

AIS = Abbreviated Injury score
ISS = Injury Severity Score
LOS = length of stay
NTDB = National Trauma Data Bank
OR = odds ratio

have attempted to address the incidence and prevention of complications after IVC ligation, most were limited by their retrospective nature and small sample sizes.[6,7,11] To our knowledge, there has been no study evaluating the effectiveness and complications in a large national cohort of patients with IVC injury who underwent ligation compared with those treated by venous repair.

Considering the high mortality rate, we hypothesized that IVC ligation could be potentially beneficial as part of a damage-control operative strategy and yield greater survival benefit compared with venous repair. The study was undertaken to determine whether ligation of the IVC injury improves survival rates compared with repair based on a large dataset from the National Trauma Data Bank (NTDB).

METHODS

The NTDB data set from 2007 to 2014 was used for the analyses. The content reproduced from the NTDB remains the full and exclusive copyrighted property of the American College of Surgeons. The American College of Surgeons is not responsible for any claims arising from works based on the original data, text, tables, or figures. The patient population analyzed in the study consisted of patients who were 18 years and older, sustained IVC injury, and underwent an exploratory laparotomy.

Patients sustaining an IVC injury were identified using the ICD-9-CM codes (902.10 and 902.19). The ICD-9 code 54.11 was used to identify patients who underwent an exploratory laparotomy and ICD-9 codes 38.7 and 38.87 were used to identify patients who underwent IVC ligation.[7] Among the remaining patients, with the exception of those undergoing IVC ligation, ICD-9 codes 39.32 and 39.56-39.59 were used to identify patients who underwent IVC repair. We excluded patients who were dead on arrival to the emergency department, did not undergo an exploratory laparotomy, did not have ICD-9 vascular procedure codes, and those who had an Abbreviated Injury Scale (AIS) score of 6 in any body region. The severity of IVC injury was expressed using AIS-98 score because the NTDB does not include the organ injury scale (see eTable 1 for AIS-98 codes used).

On the basis of the surgical procedure, patients were classified as either undergoing ligation (ligation group) or repair (repair group). Demographics and injury specific factors were compared between the 2 groups. Demographic characteristics abstracted included age, sex, systolic blood pressure, heart rate, Glasgow Coma Scale on admission, Injury Severity Score (ISS), mechanism of injury, medical history, and concomitant injuries (other intra-abdominal organs, and AIS of head, chest, abdomen, spine, and extremity).

The primary outcomes measure was in-hospital mortality. Secondary outcomes included hospital length of stay (LOS), length of ICU stay, numbers of days on mechanical ventilation, and in-hospital complication rate. Complications evaluated included extremity compartment syndrome, acute kidney injury, acute respiratory distress syndrome, deep venous thrombosis, pneumonia, pulmonary embolism, superficial surgical site infection, deep surgical site infection, and organ/space surgical site infection.

Statistical analyses

Continuous data are presented as medians with interquartile ranges, and categorical data as counts and percentages. Analysis was carried out using chi-square test and Mann-Whitney U test as appropriate. To minimize confounding effects due to nonrandomized assignment, propensity score matching was performed.[12] Propensity scores were assigned for each patient based on a logistic regression model for ligation using the 16 variables of patients and injury characteristics considering clinically or statistically significance in univariate analysis (see eTable 2). A 1:1 fixed ratio nearest neighbor matching without replacement was performed to compare outcomes of the ligation group and repair group with a caliper distance of 0.001 and priority given to exact matches. A value of $p < 0.05$ was considered statistically significant. Overall survival was calculated between the date of admission and that of death. Survival curves were plotted using the Kaplan-Meier method and compared with the log-rank test. All statistical analyses were performed using IBM SPSS for Windows, version 23.0 (IBM Corp).

RESULTS

Patient characteristics and matching

During the 8-year study period, a total of 4,865 patients treated at the NTDB-participating hospitals met all of our inclusion criteria. Figure 1 shows the flow of patient selection. After applying the exclusion criteria, 1,316 were included in the analyses. Of those, 447 patients (34.0%) underwent IVC ligation.