Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.JournalofSurgicalResearch.com

Predictors of Readmission After Cytoreductive Surgery and Hyperthermic Intraperitoneal Chemotherapy

*Anghela Z. Paredes, MD, MS, Sherif Abdel-Misih, MD, Carl Schmidt, MD, Mary E. Dillhoff, MD, Timothy M. Pawlik, MD, MPH, PhD, and Jordan M. Cloyd, MD**

Division of Surgical Oncology, Department of Surgery, The Ohio State University, Wexner Medical Center, Columbus, Ohio

ARTICLE INFO

Article history:
Received 24 April 2018
Received in revised form
3 August 2018
Accepted 7 September 2018
Available online xxx

Keywords:
HIPEC
Outcomes
Peritoneal surface malignancy
Carcinomatosis
Reoperation

ABSTRACT

Background: Risk factors for hospital readmission after cytoreductive surgery (CRS) and hyperthermic intraperitoneal chemotherapy (HIPEC) are poorly understood.

Methods: The American College of Surgeons–National Surgical Quality Improvement Program databases from 2011 to 2016 were used to identify all patients who underwent CRS-HIPEC. Demographic, clinical, and perioperative variables were examined using logistic regression to identify factors associated with 30-d postoperative readmission.

Results: Among 618 patients who underwent CRS-HIPEC, 96 (15.5%) required hospital readmission within 30 d of surgery. The incidence of readmission decreased over the study period (18.3% in 2011 to 4.8% in 2016). Among the 59 patients who were readmitted and had complete data available, readmission occurred on mean postoperative day 18.5 ± 5.5; the most common reasons for readmission were digestive complications (39.0%), postoperative infections (25.4%), uncontrolled pain (8.5%), and venous thromboembolism (5.1%). On multivariate logistic regression analysis, increasing age (OR 1.02, 95% CI 1.00-1.05), number of operative procedures (OR 1.12, 95% CI 1.00-1.25), perioperative complication (OR 7.06, 95% CI 3.96-12.59), need for reoperation (OR 10.21, 95% CI 3.50-29.83), and length of stay (OR 0.93, 0.90-0.97) were associated with hospital readmission.

Conclusions: In this population-based analysis of patients undergoing CRS-HIPEC, older age, perioperative complications, need for reoperation, and extent of cytoreduction were associated with hospital readmission. The American College of Surgeons–National Surgical Quality Improvement Program database is a powerful research tool that can be used to identify opportunities to improve the perioperative care of surgical patients.

Introduction

Since first described in the 1980s, the combination of aggressive cytoreductive surgery (CRS) and concurrent hyperthermic intraperitoneal chemotherapy (HIPEC) has become a widely adopted approach for the management of peritoneal surface malignancies.[1-7] Despite its increased utilization, CRS-HIPEC remains a complex operation with significant risks of

* *Corresponding author*. Division of Surgical Oncology, The Ohio State University, Wexner Medical Center, 410 W 10th Ave, N-907, Columbus, OH 43210. Tel.: +614-293-5365; fax: +614-366-0003.
E-mail address: jordan.cloyd@osumc.edu (J.M. Cloyd).
0022-4804/$ – see front matter
https://doi.org/10.1016/j.jss.2018.09.022

morbidity, mortality, prolonged length of hospital stay, and extended postoperative recovery, even when performed at high volume specialized centers.[8,9]

Hospital readmission is an emerging quality metric of critical importance. Hospital readmission after surgery has been associated with increased complications, mortality, hospital costs, and worse patient satisfaction.[10-13] However, specific research regarding readmissions and predictors of readmission after CRS-HIPEC is limited. In fact, few studies have reported exact readmission rates and only two have investigated specific risk factors for readmission, both of which were limited by their single-institution design and relatively small sample size.[14-18] Characterizing readmission rates using a multi-institutional population-based cohort may more accurately define relevant risk factors independent of single institutional, geographical, and surgeon biases.

Therefore, the purpose of this study was to utilize American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP), a population-based database with prospectively collected information on 30-d morbidity, mortality, and readmission rates, to define more accurately the incidence of 30-d readmission after CRS-HIPEC. In particular, we sought to identify predictors of and reasons for hospital readmission after CRS-HIPEC.

Methods

The 2011-2016 ACS NSQIP participant user data files were used to identify all patients who underwent intraperitoneal chemotherapy (CPT codes: 96549, 96446, 96445, 77620, and/or 77605) and at least one cytoreductive procedure as has been previously described.[17,19] The ACS NSQIP is a population-based data set prospectively maintained by trained abstracters with over 150 pre- and peri-operative variables as well as validated 30-d outcomes. In 2011, NSQIP began reporting 30-d hospital readmission. In 2012, NSQIP began including more complete details on reasons for readmissions. Of note, the number of indexed CRS-HIPEC cases decreased after 2012 when it was added to the exclusion list for ACS NSQIP reporting. As ACS NSQIP is a publically available deidentified database, the study was deemed exempt by the Institutional Review Board at the Ohio State University.

Data extracted for each patient included age, sex, race, American Society of Anesthesiologists score, body mass index (BMI), functional status, comorbidities including history of smoking, diabetes mellitus, presence of ascites, chronic obstructive pulmonary disease, hypertension, malnutrition, weight loss and chemotherapy in the previous 30 d, postoperative complications, length of stay, need of reoperation, discharge destination, operations performed, operative time, and unplanned 30-d readmission. Complications included superficial wound infection, need for transfusion, deep wound infection, organ space infection, wound disruption, pneumonia, unplanned intubation, pulmonary embolism, prolonged ventilator, renal insufficiency, acute renal failure, urinary tract infection, cardiac arrest, myocardial infarction, deep vein thrombosis, and sepsis. When available, date of and reason for readmission was recorded. For the purposes of the present study, ileus, obstruction, dehydration, electrolyte disturbances, and anorexia were grouped as "Digestive" reasons for readmission. Similarly, abscess, fever, urinary tract infection, pneumonia, and sepsis not otherwise specified were grouped as "Infectious" causes.

Initially, differences in patient demographic, clinical, and perioperative information were compared among patients who experienced a hospital readmission *versus* patients who did not. Mann–Whitney U test was used for bivariate analysis of continuous variables and chi-square test for categorical variables. Multivariable forward stepwise logistic regression analysis was performed to identify factors independently associated with 30-d readmission. All statistical analysis was performed using SPSS 22.0 software (SPSS Inc, Chicago, IL, USA) with significance established as $P < 0.05$.

Results

Among 618 patients who underwent CRS-HIPEC between 2011 and 2016 in the ACS NSQIP database, 96 (15.5%) experienced a 30-d readmission, whereas 522 (84.4%) did not. In general, the readmission rate decreased steadily throughout the study period (Fig. 1; 18.3% in 2011 to 4.8% in 2016). Table 1 lists the preoperative demographic and clinical characteristics of patients who were and were not readmitted after CRS-HIPEC. While patients who required readmission were older (56.5 *versus* 53.5 y, $P = 0.03$), there were no other differences between the two groups (all $P > 0.05$).

Table 2 compares the perioperative outcomes of patients who underwent CRS-HIPEC relative to readmission. While there was no association between the type of cytoreductive procedures performed and readmission, those patients readmitted were more likely to have had a greater number of operative procedures performed at the time of surgery (7.3 *versus* 6.7, $P = 0.03$) and had a longer operative time (491 *versus* 451 min, $P = 0.03$). With regard to postoperative outcomes, patients who required readmission were also more likely to have experienced a postoperative complication (56% *versus* 20%, $P < 0.001$) and require a reoperation (21% *versus* 3%, $P < 0.001$). When individual complications were further evaluated, deep wound infection ($P = 0.02$), organ space infection ($P < 0.001$), wound disruption ($P = 0.03$), pulmonary embolism ($P = 0.02$), renal insufficiency ($P < 0.01$), and sepsis ($P < 0.001$) were all associated with readmission risk (Table 2). Interestingly, there was no difference in length of stay ($P = 0.34$) or discharge destination relative to readmission ($P = 0.32$).

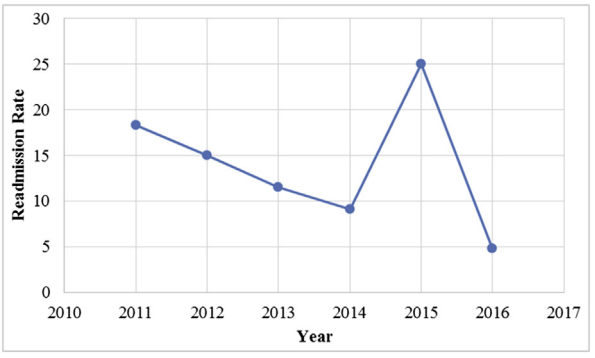

Fig. 1 – Changes over time in readmission rates after CRS-HIPEC. (Color version of figure is available online.)