Review Article

Perioperative fluid management in major hepatic resection: an integrative review

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BACKGROUND: Fluid intervention and vasoactive pharmacological support during hepatic resection depend on the preference of the attending clinician, institutional resources, and practice culture. Evidence-based recommendations to guide perioperative fluid management are currently limited. Therefore, we provide a contemporary clinical integrative overview of the fundamental principles underpinning fluid intervention and hemodynamic optimization for adult patients undergoing major hepatic resection.

DATA SOURCES: A literature review was performed of MEDLINE, EMBASE and the Cochrane Central Registry of Controlled Trials using the terms "surgery", "anesthesia", "starch", "hydroxyethyl starch derivatives", "albumin", "gelatin", "liver resection", "hepatic resection", "fluids", "fluid therapy", "crystalloid", "colloid", "saline", "plasma-Lyte", "plasmalyte", "hartmann's", "acetate", and "lactate". Search results for MEDLINE and EMBASE were additionally limited to studies on human populations that included adult age groups and publications in English.

RESULTS: A total of 113 articles were included after appropriate inclusion criteria screening. Perioperative fluid management as it relates to various anesthetic and surgical techniques is discussed.

CONCLUSIONS: Clinicians should have a fundamental understanding of the surgical phases of the resection, hemodynamic goals, and anesthesia challenges in attempts to individualize therapy to the patient's underlying pathophysiological condition. Therefore, an ideal approach for perioperative fluid therapy is always individualized. Planning and designing large-scale clinical trials are imperative to define the optimal type and amount of fluid for patients undergoing major hepatic resection. Further clinical trials evaluating different intraoperative goal-directed strategies are also eagerly awaited.

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KEY WORDS: hepatic resection; liver resection; fluid therapy; anesthesia; crystalloid; colloid; goal-directed therapy

Introduction

Hepatic resection is a well-established treatment for various liver pathologies with a morbidity rate of up to 25% and reported mortality of up to 5%;[1-3] however, major blood loss and subsequent blood transfusion are common.[4-7] Perioperative fluid intervention and vasoactive pharmacological support during major hepatic resection depend on the preference of the attending clinician, institutional resources, and practice culture. The scientific literature provides little evidence-based guidance regarding the amount (quantitative fluid intervention) or type (qualitative fluid intervention) of fluid to optimize outcomes during major hepatic resection. Judicious fluid management is an important strategy to minimize blood loss during hepatic resection;[4] however, there are no guidelines for optimal care. Therefore, perioperative fluid management and hemodynamic optimization need to be individualized to account for patient factors and the complexity of surgery. We provide a contemporary integrative overview of the fundamental principles underpinning fluid intervention and hemodynamic optimization for adult patients undergoing major hepatic resection.

Search strategies and results

A literature review was performed of MEDLINE, EMBASE, and The Cochrane Central Registry of Controlled

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Trials from January 1965 to December 2016 with the following keywords: "surgery", "anesthesia", "starch", "hydroxyethyl starch derivatives", "albumin", "gelatin", "liver resection", "hepatic resection", "fluids", "fluid therapy", "crystalloid", "colloid", "saline", "plasma-Lyte", "plasmalyte", "hartmann's", "acetate", and "lactate". Search results for MEDLINE and EMBASE were additionally limited to studies on human populations that included adult age groups and publications in English. Only published titles and abstracts evaluating the fluid intervention with relevance to major hepatic resection were included. Three authors conducted the search and data extraction (YO, PMV and WL). Two authors analyzed the results (YO and WL). A two-stage process was used for study selection. First, two review authors (YO and WL) independently screened the titles and, if available, the abstracts of the search results to determine if a study met the inclusion criteria. We defined major hepatic resection as the removal of three or more segments and only included papers covering minor hepatic resection if they had specific implications for fluid intervention. Each article was classified as follows: duplicate of another citation, unclear, included, or excluded. References given in the publications were manually assessed for further inclusion in this study. Disagreements were assessed by a third author (PMV) and resolved by consensus. Authors had access to full-text original papers.

In total, after appropriate screening against the inclusion criteria, we retrieved 763 references or full-text journal articles for analysis and critical review (Fig. 1). Including online journal articles and textbooks, 113 articles were included in this review.

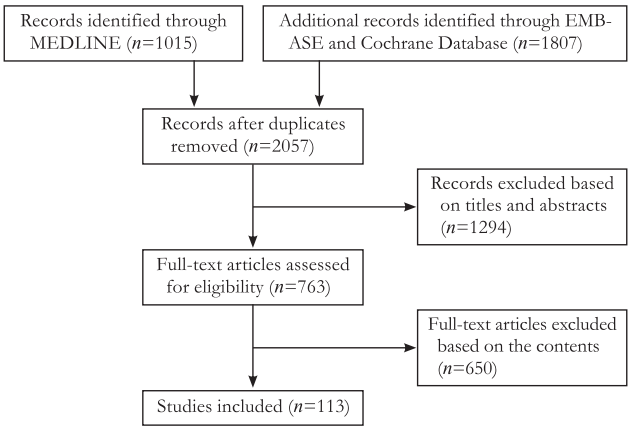

Fig. 1. Study selection of flow diagram.

Major blood loss during hepatic resection: a changing landscape

A study by Foster from nearly 40 years ago evaluated patients undergoing major hepatic resection and reported a mortality rate of greater than 20%.[3] The leading cause of death was hemorrhage directly related to hepatic parenchymal transection resulting in massive intraoperative and postoperative exsanguination. Over the last two decades, blood loss associated with hepatic resection has significantly decreased, with intraoperative losses of less than 500 mL now commonly reported in high-volume centers[8-10] and mortality rates as low as 0.[9] There is a strong association between intraoperative blood loss and major morbidity and in-hospital mortality; however, intraoperative blood loss during hepatocellular carcinoma resection is also an independent prognostic factor for tumor recurrence and long-term disease survival.[5] As the numbers of surgical techniques and innovative strategies to minimize blood loss improve, the leading causes of death in major hepatic resection continue to shift away from massive perioperative exsanguination and toward hepatic failure and infectious complications.[11-15] Notably, post-surgical pulmonary complications are also common and include pleural effusion, atelectasis, pneumonia, and pulmonary congestion.[9, 13, 16] The development of these complications may be directly caused or adversely impacted by improper fluid management.[17]

Surgical techniques that impact blood loss and fluid intervention

Hepatic resection can be broadly divided into three surgical phases. The first phase involves mobilization and control of inflow and outflow. During this stage, major hemorrhage is usually uncommon; however, massive blood loss from unexpected vascular injury can be profound, and clinicians should always be prepared for rapid and aggressive fluid resuscitation. Hypotension can occur if the liver pushes against the vena cava, which impairs venous return to the heart and is reversible upon returning the liver to its normal anatomical position. The second phase involves parenchymal resection beginning with the transection of the liver parenchyma and concluding when the resection is completed. If a vascular occlusion strategy is applied, sudden changes in circulation volume may significantly influence fluid and anesthetic management. Furthermore, pharmacological support, including inotrope with or without fluid intervention, may require maintaining organ perfusion pressure. Intraoperative hemorrhage primarily occurs in this phase. Strategies involved in inflow and outflow control include the Pringle maneuver, liver exclusion, total or partial clamping of the interior vena cava and the