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ORIGINAL ARTICLE

Robotic pancreatoduodenectomy at an experienced institution is not associated with an increased risk of post-pancreatic hemorrhage

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Abstract

Background: Postpancreatectomy hemorrhage (PPH) is a serious and life threatening complication following pancreaticoduodenectomy. The objective was to determine whether PPH incidence is elevated in a series of robotic pancreatoduodenectomy (RPD) from a high-volume institution and if video review can identify technical factors associated with PPH.

Methods: A retrospective review of RPDs from October 2008 to March 2016 was performed. PPH was classified by established international criteria. Technical factors from RPD resection were ascertained using video analysis. Clinical and technical variables were analyzed using multivariate analysis.

Results: Of 400 patients who underwent RPD PPH occurred in 19 (4.8%) and 168 (42%) had videos available to review. The technique of RPD was consistent but a falciform flap was performed routinely after RPD#181 and flaps were performed less (37.5% vs 75%) in the pseudoaneurysm group ($p = 0.033$). On univariate analysis of technical variables, gastroduodenal artery (GDA) mishandling and suture ligation were positive predictors of pseudoaneurysm formation while falciform flap placement was a negative predictor (all $p < 0.05$). GDA suture ligation remained significant on multivariate analysis ($p = 0.006$). A negative relationship was found between pseudoaneurysm occurrence and time ($\rho = -0.533$; $p < 0.05$).

Conclusions: PPH in a large series of RPD is similar to reported rates in historical open control series; however, pseudoaneurysm is less common with increasing experience. Video review is a useful tool in identifying technical variables during in RPD.

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Introduction

Postpancreatectomy hemorrhage (PPH), especially pseudoaneurysm formation, is the Achilles heel of pancreaticoduodenectomy[1] (PD), and though seen in less than 10% of patients, accounts for 11–38% of mortality.[2] The International Study Group of Pancreatic Surgery (ISGPS) has clinically graded PPH based on onset, location, and severity.[3] Exposed arteries, most commonly the gastroduodenal artery, can be damaged by tumor invasion, extensive surgical skeletonizing, or postoperative inflammation related to an abdominal abscess or more commonly postoperative pancreatic fistula (POPF). Damaged arteries cannot withstand intraluminal hydrostatic pressure, which leads to the development of a pseudoaneurysm, one cause of PPH.[4] Though Lee *et al.*[5] reported a median period of 21 days for pseudoaneurysm bleeding to occur after pancreatic resections, massive arterial bleeding can occur late in the postoperative period beyond 4 weeks.[6] This bleeding can be intraluminal or extra-luminal and recognition and triage is important to avoid postoperative death.

Historically, pseudoaneurysms have been managed with surgical intervention, however, owing to advances in interventional radiology, the paradigm has greatly shifted towards endovascular treatment.[7] Management of early PPH within the first 5 days following the index operation depends on whether bleeding is located intra-luminally or extra-luminally.[8] "True" extra-luminal

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PPH is mostly due to insufficient hemostasis, usually occurs within 24–48 h postoperatively, and often requires immediate re-laparotomy without diagnostic delay. "False" extra-luminal PPH resulting from disruption of the pancreaticoenteric anastomosis with subsequent evidence of bleeding via abdominal drains has a reasonable chance to be treated by interventional radiology.[9]

As minimally invasive pancreaticoduodenectomy (MIPD) has been implemented,[10] concerns of safety, including PPH, have been raised.[11,12] In the early experience at the University of Pittsburgh, a pseudoaneurysm in the absence of POPF caused concern that in the absence of haptic feedback during robotic Pancreatoduodenectomy (RPD), grasping arteries with unknown strength, could cause adventitial injury, thus no-touch techniques were later adopted.[12] The objective of this report is to determine whether PPH incidence is elevated in a large, series of RPD and to identify technical factors which may contribute to pseudoaneurysm using blinded video review. Though early reports of MIPD have shown increased incidence of PPH, it remains unclear whether this is related to early experience, artificial elevation in the absence of a larger cohort, or a pitfall of the technique. We hypothesize that the incidence of PPH for RPD will not be higher than historical controls. We further hypothesized that review of a video database may identify potentially correctable technical causes of pseudoaneurysm.

Methods

Patient variables and outcomes

A retrospective review of patients undergoing RPD from October 2008 to March 2016 was performed. The study was approved by the University of Pittsburgh institutional review board (PRO16080543), and all procedures were performed by surgeons with extensive experience in pancreatic surgery and include all patients undergoing RPD since its introduction in our hospital and including all patients reported in a previous analysis which identified the learning curve.[13] The operative procedures were undertaken in a standard manner but falciform flaps were routinely performed to cover the GDA stump after RPD#181. Data retrieved prospectively by a research assistant included: patient demographic information, clinical presentation, clinical stage, treatment, 90-day morbidity and mortality, and oncologic outcomes. POPF was defined according to the original ISGPS Fistula Definition recommendations which include Grade A fistulas, now considered biochemical leaks.[14,15] PPH was classified by ISGPS criteria.[3] PPH was categorized as a pseudoaneurysm or non-pseudoaneurysm, and the pseudoaneurysm group was used for comparative analysis. All patients were diagnosed with pseudoaneurysm based on clinical factors and radiographic confirmation and were re-reviewed retrospectively for additional information.

Technical variables

The video library breaks RPD into seven steps. The second step of the operation is the porta hepatis and includes: removal of the 8A lymph node, dissection of the common hepatic artery, gastroduodenal artery (GDA), right gastric, and hepatic artery proper. Additionally, circumferential dissection of common bile duct including portal vein and replaced right hepatic artery (if present), creation of the tunnel under the pancreatic neck, and transection of the pancreas is within this step. Step #2 was reviewed during video analysis. Technical factors from retrospective video analysis were reviewed for variables including: anomalous arterial anatomy, mishandling vessels, method of GDA ligation (suture ligation vs stapler), length of GDA stump, placement of arterial clip, and creation of a falciform flap. Suture ligation was a double ligation technique performed with 2-0 silk ties and a 5-0 prolene. Endo-GIA Staplers (Covidien, Dublin, Ireland) were used with 45 mm vascular gold loads with a curved tip. A 10-mm automatic laparoscopic clip-applier was used to mark the GDA in addition on either the stitch or staple line. Mishandling vessels, common hepatic artery and GDA, was defined by direct contact via grabbing and manipulation of vessel with robotic instruments, in contrast to handling the connective tissue adjacent to vessels or pushing away without grabbing the vessel – "the spatula technique". These variables as well as the previously discussed clinical variables were compared between patients with RPD videos and those without as well as between patients with diagnosed pseudoaneurysm and those without.

Statistical analysis

Descriptive statistics were reported as the number (percentage) or mean with standard deviation as appropriate. Normalcy testing was done and non-parametric tests were used when indicated. Univariate associations of variables with pseudoaneurysm formation were assessed using binary logistic regression reporting the odds ratio and 95% confidence interval. Clinical and technical variables were analyzed using multivariate analysis for pseudoaneurysm formation. To determine whether operative experience diminished the occurrence of pseudoaneurysm, the first 200 RPDs were compared to the second cohort of 200 RPDs. The relationship between frequency of pseudoaneurysm and time was analyzed using a polynomial regression equation. The alpha level was set at 0.05 for statistical significance. Statistical analyses were performed using IBM SPSS statistical software (SPSS for Apple, version 23: Chicago, IL).

Results

In eight years, 400 patients underwent RPD with 19 (4.8%) patients diagnosed with PPH, 16 of which were pseudoaneurysms and were used for subsequent analysis to assess potential vascular trauma. Of the three PPH patients that did not have a pseudoaneurysm: two had true extraluminal bleeds from the lesser curvature staple line (one underwent further laparotomy) and one patient had an intraluminal bleed from the gastrojejunal anastomosis. For pseudoaneurysms (n = 16), diagnostic modalities utilized were CT (n=1), angiographic (n=11), or both

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