

# Early Ligation of the Inferior Pancreaticoduodenal Artery Using Intraoperative Ultrasonography during Pancreaticoduodenectomy

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## Abstract

**Background:** While the safety of pancreaticoduodenectomy (PD) has improved, the high level of difficulty associated with this operation means that the procedure carries a high mortality rate compared to other gastrointestinal operations. Various trials have been implemented in efforts to reduce the incidence of complications after PD. In particular, a large amount of intraoperative bleeding and the use of red blood cell transfusions are reportedly risk factors for postoperative complications after PD. **Aim:** In an attempt to reduce the amount of intraoperative bleeding during PD, consideration was given to the anatomical characteristics of the region of the pancreatic head, and the gastroduodenal artery (GDA) and inferior pancreaticoduodenal artery (IPDA) were ligated in advance of separating the head from the portal vein. We herein report the use of ultrasonography during PD to facilitate the early identification and ligation of the IPDA. **Case Presentation:** A 72-year-old female was diagnosed with pancreatic cancer and underwent pylorus-preserving pancreatoduodenectomy. We used ultrasonography during the operation to initially identify the IPDA and then ligate it in advance, after which the GDA was ligated before separating the pancreatic head from the superior mesenteric artery and portal vein. Identification of the IPDA was performed with the SMA as a guide using ultrasonography in Doppler mode. The amount of intraoperative bleeding was 235 ml. The patient left the hospital without any postoperative complications and has since demonstrated a good postoperative course, with no evidence of recurrent disease. **Conclusions:** Early ligation of the IPDA using intraoperative US is non-invasive and makes it simple to identify the IPDA. This method may be a useful technique for reducing intraoperative bleeding during the normal course of PD procedures.

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## Keywords

**Intraoperative Bleeding, Early Ligation, Inferior Pancreaticoduodenal Artery, Pancreaticoduodenectomy, Ultrasonography**

## 1. Introduction

Pancreaticoduodenectomy (PD) has been established as a standard procedure for treating tumors in the pancreatic head region. Recently, however, while the safety of PD has improved, the difficulty of this operation means that the procedure reportedly has a relatively high mortality rate of between 1.2% and 6% [1]-[3]. Concomitant conditions that may occur subsequent to PD are reported to include, in the early stages, pancreatic and/or biliary fistula formation, gastrointestinal bleeding, intra-abdominal abscess formation, pulmonary complications and delayed gastric emptying, and, in later stages, diabetes, diarrhea and malnutrition, with between 30% and 60% of patients thought to experience these symptoms [4]-[6]. Among these complications, it has been reported that significant blood loss occurring during the operation, as well as the use of blood transfusions, is a risk factor for postoperative complications and that controlling intraoperative bleeding is therefore an extremely important issue [7]-[10]. Various trials have been implemented in efforts to reduce postoperative complications after PD. However, there are almost no reports of attempts to reduce intraoperative bleeding during PD.

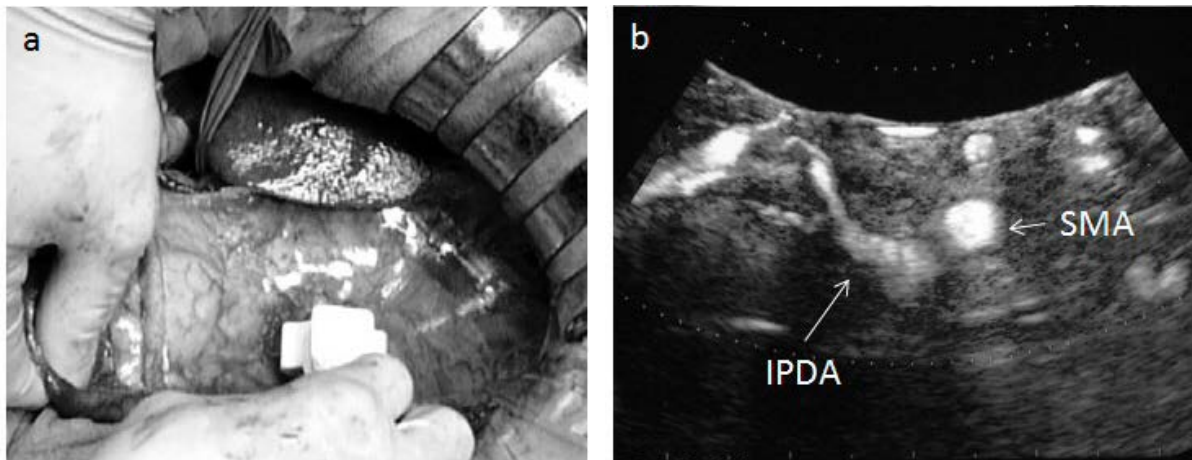
The arterial blood supply of the head of the pancreas is mainly provided by the anterior and posterior pancreaticoduodenal arcades. Both arcades are formed by a superior and inferior root coming from the gastroduodenal artery (GDA) and inferior pancreaticoduodenal artery (IPDA), respectively. In regular PD procedures, only the GDA is initially ligated before separating the pancreatic head from the portal vein. According to these procedures, the blood flow in the head of the pancreas from the IPDA remains, which may result in significant blood loss at the stage at which the pancreatic head is separated from the portal vein. In one report, in an attempt to reduce intraoperative bleeding during PD, consideration was given to the anatomical characteristics of the pancreatic head region and both the GDA and IPDA were ligated before separating the pancreatic head from the portal vein [11]-[13]. In the current study, we report the use of ultrasonography during PD to facilitate the early identification and ligation of the IPDA.

## 2. Case Report

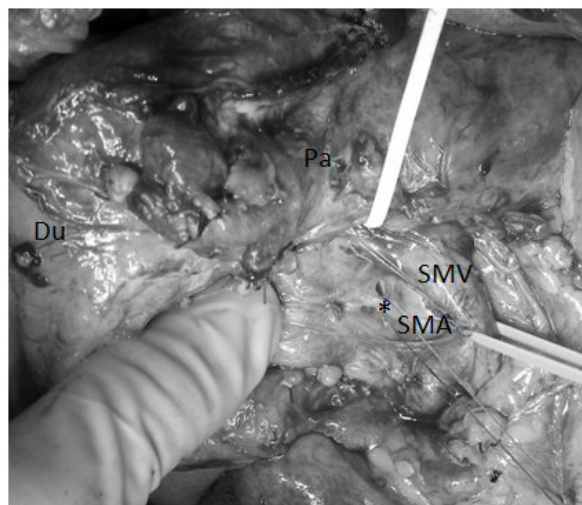
A 72-year-old female was admitted to our hospital with a one-year history of intermittent pancreatitis. At the initial presentation, a physical examination was remarkable only for mild tenderness in the epigastrium. A computed tomography (CT) scan of the abdomen showed a small cyst in the pancreatic head. Endoscopic retrograde cholangiopancreatography (ERCP) demonstrated severe localized stenosis of the main pancreatic duct (MPD) and pooling of medium in the pancreatic head. Endoscopic ultrasonography (EUS) revealed a hypoechoic mass measuring 25 × 15 mm close to the site of stenosis of the MPD. Pancreatic cancer was thus diagnosed, and pylorus-preserving pancreatoduodenectomy was conducted.

The method for performing early ligation of the IPDA using intraoperative ultrasonography was as follows: 1) the duodenum was removed at a point 3 cm from the pylorus ring. 2) The gallbladder was extirpated, and the duodenal ligament was dissected. 3) The pancreatic head was subjected to Kocher's maneuver, and the superior mesenteric artery (SMA) was identified. 4) Tunneling was implemented on the anterior surface of the pancreatic head and the SMA. 5) The jejunum was cut at a point approximately 10 cm from the ligament of Treitz. 6) The IPDA was identified using ultrasonography in Doppler mode (**Figure 1(a)**). It is simple to identify the SMA using ultrasonography. The SMA was therefore used as a marker to identify the IPDA running into the pancreatic uncus (**Figure 1(b)**), which was then ligated and removed (**Figure 2**). 7) Subsequent to ligation and removal of the GDA, the pancreatic head was detached from the SMA. 8) Child's reconstruction was implemented, and the PD procedure was completed. There are no differences in the technique between regular PD and our method without early ligation of the IPDA using intraoperative US.

The amount of intraoperative bleeding was 235 ml, and the patient did not receive any blood transfusions. She was discharged on the 21st postoperative day without any postoperative complications and has since demonstrated a good postoperative course, with no evidence of recurrent disease for three years after the surgery.



**Figure 1.** (a) The inferior pancreaticoduodenal artery (IPDA) was identified using intraoperative ultrasonography in Doppler mode; (b) The IPDA branched directly from the superior mesenteric artery (SMA).



**Figure 2.** The IPDA, which was identified using intraoperative ultrasonography, was ligated before separating the pancreatic head from the portal vein. Du: duodenum, Pa: pancreas, SMV: superior mesenteric vein, SMA: superior mesenteric artery, asterisk: inferior pancreaticoduodenal artery.

### 3. Discussion

Compared to other types of gastrointestinal operations, PD is a procedure associated with relatively frequent complications. Significant blood loss during the operation and the use of blood transfusions are important risk factors for postoperative complications after PD [14]. The most complex operative procedure employing the PD technique, which carries the highest risk of increased blood loss, is the maneuver used to separate the pancreatic head from the superior mesenteric artery and portal vein. If the volume of blood lost during this procedure could be reduced, it may be possible to significantly decrease the volume of blood loss during the entire PD operation. In this study, we used ultrasonography to facilitate the early identification and ligation of the IPDA with the objective of reducing the amount of blood loss during PD.

The arterial blood supply of the head of the pancreas is mainly provided by the anterior and posterior pancreaticoduodenal arcades. Both arcades are formed by a superior and inferior root coming from the GDA and IPDA, respectively.

In regular PD procedures, only the GDA is initially ligated prior to pancreatectomy. Since it is not simple to identify the IPDA, in many cases, it is ligated directly prior to extirpation of the pancreatic head. In such cases, the blood flow remains, as a result of the arcade in the head of the pancreas to be removed, and the blood vessels

that flow into the portal vein from the pancreatic head are cut, thereby causing hemostasis in the pancreatic head and thus facilitating the onset of bleeding. As a result, there is a significant amount of blood loss in the final stage of the PD procedure.

Ordinarily, the IPDA branches from the SMA, although there are often anomalies in its course. Reported techniques for early ligation of the IPDA include a method by which the IPDA is identified on CT angiography implemented prior to performing the operation (CLIP method: preoperative CT image-assessed ligation of the IPDA) [11] and/or the implementation of Kocher's maneuver, after which the IPDA is identified following further detachment along the right margin of the SMA (back-approach) [12], both of which significantly reduce intraoperative bleeding [13]. In the current case, we used ultrasonography during the operation to initially identify the IPDA and then ligate it in advance, after which the GDA was ligated before separating the pancreatic head from the superior mesenteric artery and portal vein. Identification of the IPDA was performed with the SMA as a guide using ultrasonography in Doppler mode. Subjecting the pancreatic head region to Kocher's maneuver and identifying the SMA before subjecting the portal vein to tunneling made it simple to identify the SMA using intraoperative ultrasonography. Employing the SMA as a marker, the IPDA was identified as it flowed into the pancreatic uncus. The IPDA is reported to branch via the primary jejunal artery in 57.6% of cases, directly from the SMA in 24.0% of cases and separately into the anterior IPDA and posterior IPDA in 18.4% of cases [15]-[17]. In the present case, it branched directly from the SMA.

We herein reported a case in which intraoperative ultrasonography was used to achieve early ligation of the IPDA during the normal PD procedure. Our method is non-invasive and makes it simple to identify the IPDA. This method may be useful for reducing the amount of intraoperative bleeding during the normal course of PD procedures.

## Conflict of Interest

None of the authors have any conflicts of interest associated with this study.

## Financial Disclosure

We have no disclosures or any financial support.

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