A “Hub and Spoke” Model for Pancreaticoduodenectomy across the Indonesian Archipelago

Toar Jean Maurice Lalisang¹, Yarman Mazni¹, Sahat Matondang²

¹ Department of Surgery, Faculty of Medicine, Universitas Indonesia, dr. Cipto Mangunkusumo General Hospital, Jakarta, Indonesia.

² Department of Radiology, Faculty of Medicine, Universitas Indonesia, dr. Cipto Mangunkusumo General Hospital, Jakarta, Indonesia.

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*Corresponding author:

Toar JM Lalisang
Department of Surgery, Faculty of
Medicine, dr. Cipto Mangunkusumo
General Hospital, Jakarta 10430,
Indonesia
Email: toar.m@ui.ac.id

ABSTRACT

Background: Pancreaticoduodenectomy (PD) is associated with major morbidity and mortality especially in low volume centers. A centralized model is not suitable for Indonesia, due to its geographical characteristics and the underlying structure of its health funding. As an alternative, an outreach program was developed and delivered by a dedicated hepatopancreatobiliary (HPB) team. The aim of this study was to describe the outcomes of such approach.

Methods: A retrospective study of all patients undergoing Pancreaticoduodenectomy or total pancreatectomy by a single HPB team was performed. A “hub and spoke” model /decentralization strategy was used to deliver the care between a tertiary center and eight peripheral centers. Patient demographics, system measures, and outcomes were collected.

Results: A total of 213 patients were identified as undergoing a resection within the period of 1993–2017. A total of 47 resections (22%) were performed at a peripheral center. The median age was 51 years and 91(46%) of patients had ampullary carcinoma. The perioperative mortality was 17% but improved over time. Only 19/198 (9.5%) patients with the malignant disease received adjuvant therapy. The median (95%CI) survival for patients with pancreatic and ampullary cancer was 12 (9-15) and 24 (14-34) months respectively.

Conclusions: A hub and spoke model as a decentralization strategy for managing patients with peri-ampullary tumors can lead to an improvement in access and outcomes. However further work is required if they are to achieve outcomes achieved by international high-volume centers within centralization programs.

INTRODUCTION

Resection is the treatment of choice for periampullary tumors, and in those with malignancy, the addition of adjuvant chemotherapy has been shown to improve survival [1–4]. However, Pancreaticoduodenectomy (PD) is associated with high morbidity and mortality, especially in low volume centers [5–8]. In countries with a well-resourced healthcare system, there has been a shift to the centralization of PD as an effort to reduce perioperative mortality and to improve long term outcomes [6, 9, 10]. However, for several other countries, such approach may not be feasible. For example, within Indonesia, barriers to instituting a centralized approach include the

lack of well-established healthcare and/or transport infrastructure to support centralized care, absence of appropriate funding models, poor social acceptance, and lack of well-trained surgeons.

To achieve an optimal outcome for patients undergoing PD, multiple factors need to be addressed. This includes a multidisciplinary team to optimize preoperative decision making, a well-trained and specialized surgical team, and a tertiary level hospital with 24-hour access to multi-disciplinary services [11–14]. Unfortunately, an established centralized model (mobilizes patient to a tertiary center) is not feasible in Indonesia. The geographical characteristics as a vast archipelago consisting of 5 big islands and 17.000 small or medium islands with 265x106 residents living in 34 provinces is a significant barrier. In addition, healthcare

funding does not “follow a patient” and patients are reluctant to travel due to financial barriers associated with such approach. Previous attempts to overcome these barriers have used a decentralized strategy similar to a “hub and spoke” model [15]. There is a lack of published literature describing successful alternative models of care for patients with pancreatic disease in countries who suffer similar problems as Indonesia.

To overcome the above issues, an alternative approach has been instituted. A “hub and spoke model” where a well-trained hepatopancreatobiliary (HPB) surgeon with a dedicated team, travel to perform surgical procedures at the local hospital and then provide remote postoperative assistance. The aim of this study was to review the outcome of such an approach.

METHODS

A retrospective study was performed by identifying all patients who underwent PD or total pancreatectomy during the period of January 1993 to December 2017 by HPB team of dr. Cipto Mangunkusumo Hospital (CMH), the “hub” hospital. The included patients in whom surgery was performed at the tertiary center or one of eight peripheral hospitals surrounding Jakarta in the average radius of 10 km (non-CMH), the “spoke” hospital. This mobile surgical team applied a decentralized strategy. The first step was to provide preoperative assessment, followed by decision making at a multi-disciplinary clinic-pathological conference at CMH. All peripheral hospitals had standard facilities for major surgery and postoperative care. A team of HPB surgeon from CMH carried out the operations in accordance with the standard procedure. Post-operative care and follow-up were performed by local surgeons at the peripheral hospital who routinely communicated the progress to the HPB team at CMH. Post-operative complications were discussed with the HPB surgeon, and treatment plans were decided accordingly. If re-laparotomy was needed, the HPB surgeon would travel to perform the surgery or the patient would be transferred. If that was not possible, local surgeons would perform surgery as required. Interventional radiology is available in the central hospital, but interventional endoscopy is available in all local hospitals. Adjuvant chemotherapy was not routinely administered, but selectively based on local availability.

Patient characteristics and perioperative variables were collected and analyzed. Morbidity was retrospectively reported. The pancreatic fistula was defined as per International Study Groups on Pancreatic Surgery (ISGPS) criteria [16]. Operative mortality was defined as those died within 30 days following surgery, or during hospitalization. Date of last follow up (review of records) was 31 December 2017.

The subjects were divided into two groups: those who were treated at CMH (tertiary center) and those who were treated at the peripheral hospitals. Normality data distribution will be tested. Nominal data are presented as n (%) and continuous data as median (range). Mann-Whitney U test, Fischer exact and chi-squared tests were used appropriately. Cumulative summation (CuSum) analysis [1, 17–19] was performed using operative mortality as the binary outcome. CuSum calculates the cut-off number of surgeon competence to perform the procedure. The acceptable mortality rate was set at 5% and the unacceptable mortality rate was 20% based on published data from low and high volume units [6, 7, 9–11], with type I and II error set at 0.10. Kaplan–Meier analysis used in the evaluation of survival. The p-value of <0.05 regarded as significant.

RESULTS

A total of 213 patients were identified, 211 (99%) of them underwent PD, and two (1%) of them underwent total pancreatectomy. Forty-seven (22%) patients underwent surgery at a peripheral hospital. Demographics, specific preoperative data, surgical procedures, and morbidity with the perioperative mortality are shown in **Table 1**.

Histology of the resected specimens were pancreatic ductal adenocarcinoma (PDAC) in 70 (35%), ampullary adenocarcinoma (AVAC) in 91 (46%), duodenal adenocarcinoma (DAC) in 21 (11%), other malignant pathologies in 16 (8%), and benign in 15 (7%) patients. Of the 208 patients with malignant disease, 19 (9%) received adjuvant chemotherapy.

Figure 1 shows cumulative mortality for sequential pancreatic resections performed using a hub and spoke model from 1993-2017 for patients presenting or referred to CMH. Expected mortalities are shown based on published mortalities from low and high-volume units. The curve shows a gradual improvement in perioperative mortality over time. After 100 pancreaticoduodenal resections (PDR) the operative mortality was on the accepted zone. The area between the black and red line was the accepted zone.

Figure 2 shows the sequential probability ratio analysis of mortality following pancreatic resection within the period of 1993-2017. An unacceptable mortality rate was set at 20% and an acceptable mortality rate at 5%. α and β were set at 0.10. H_0 or H_1 were set to be accepted or rejected at $P=0.001$. Two resets can be seen concluding that mortality was exceeding 20% at procedure number 46 and 102. Since that time no further resets have occurred. It cannot yet be concluded that mortality of <5% has been achieved. Each horizontal grid line on the y-axis represents a control line.

Table 1. Demographic and specific perioperative data in CMH and non CMH groups

Group	CMH (n = 166) 77.9%	Non-CMH (n = 47) 22.1%	p value	Total (n = 213)
Male Gender	80 (48)	15 (32)	0.045	95 (45)
Age (year)	50 (17 – 73)	53 (27 – 71)	0.175	51 (17 – 73)
Number of patients presenting with obstructive jaundice	116 (70)	33 (70)		149 (70)
Duration of symptoms (month)	2 (0.25-4.5)	1 (0.5- 3)		2 (0.25-4.5)
Preoperative bile duct decompression	96 /116 (83)	23/33 (70)	0.365	119 (80)
Intraoperative duration of operation (min)	420 (245 – 640)	480 (360– 700)	0.002	430 (245 – 700)
Blood loss (mL)	600 (100 – 3000)	400 (200 – 1100)	<0.001	500 (100 – 3000)
Pyloric-preserving PD	99 (60)	28 (60)		127 (60)
PD	65 (39)	19 (40)	0.591	84 (40)
Total pancreatectomy	2 (1)	0 (0)		2 (1)
Morbidity	105 (63)	34 (79)	0.164	139 (65)
Re-laparotomy	26 (16)	5 (11)	0.641	31 (15)
Post-pancreatectomy hemorrhage	15 (9)	4 (9)	1.000	19 (9)
Surgical site infection	39 (24)	19 (40)	0.080	57 (27)
Pancreatic fistula	33 (20)	10 (21)	0.294	43 (24)
ISGPS type A/B/ C	3/20/10	3/3/4		6/23/14
Delayed gastric emptying	19 (11)	5 (11)	0.923	24 (14)
Pneumonia	6 (4)	0 (0)	0.344	6 (3)
Aspiration	2 (1)	0 (0)	1.000	2 (1)
Operative Mortality	29 (18)	7 (15)	0.844	36 (17)
Length of stays (days)	15 (2 – 48)	15 (5 – 42)	0.943	15 (2 – 48)

CMH: Cipto Mangunkusumo Hospital, PD: pancreaticoduodenectomy, ISGPS: International Study Groups on Pancreatic Surgery.

Figure 1. Cumulative mortality for sequential pancreatic resections performed using a hub and spoke model from 1993-2017 for patients presenting or referred to CMH

Figure 2. Sequential probability ratio analysis of mortality following pancreatic resection within the period of 1993-2017

At the end of the follow-up period, 130 (73%) patients had died. Both patients who underwent total pancreatectomy died within 6 months after surgery due to unsuccessful management of severe hypoglycemia. The overall 5-year survival was 21% and the median (95%CI) survival was 19 (13-25) months, showed in **Figure 3**.

Figure 3. Overall Survival of pancreaticoduodenectomy resection of 213 patients with Peri-ampullary tumors (1993-2017)

The 5-year survival for patients with PDAC and AVAC was 19% and 29% respectively. The median (95%CI) survival for patients with PDAC and AVAC were 12 (9-15) and 24 (14-34) months respectively (**Figure 4**), with $p=0.022$.

Figure 4. Kaplan-Meier survival curve for Pancreatic Ductal Adenocarcinoma (PDAC), and Ampullary Adenocarcinoma (AVAC)

DISCUSSION

The delivery of high-quality care to patients presenting with peri-ampullary tumors in healthcare systems without the ability or resources to centralize surgery is problematic [20, 21]. This descriptive study documented the outcomes of patients over a 24-year period, during which time a “hub and spoke” model was deployed in an effort to improve access to and the quality of care provided within an Indonesian healthcare system.

The implementation of such model was found effective for both patients and surgeons. Patients gained access to discussion of their care at a standardized multidisciplinary team meeting and to a dedicated HPB surgical team close to home [15, 21]. For the surgical team, the greater experience was achieved with annual resection volumes reaching as high as 24 per year [15, 20, 21].

Using cumulative summative (CuSum) analysis, an improvement in perioperative outcomes could be observed in the latter half period of the study. This was similar to what has been previously reported by others [10, 21]. However, these outcomes have not yet reached what was reported from modern series in centers with centralization [6, 7, 9]. Whether that can ever be achieved remains to be seen. Given the morbidity rates including the fact that the pancreatic specific rates are similar to those reported elsewhere, it would seem likely that the reason for the excess mortality is due to failure to rescue [5, 22–25]. This poses challenges on how to improve this aspect of perioperative care especially when access to interventional radiology is limited. Less blood loss and shorter surgery duration were due to the usage of surgery devices but they do not influence the patient's output. It is worth noting that the outcomes, however, did not seem to be different between the peripheral and central hospital suggesting that the perioperative management of preventing or treating complications may need further analysis.

The long term outcomes are also worth noting as only 9.5% of patients received adjuvant chemotherapy, yet patients with PDAC surgery alone makes very little difference to the long term survival [1, 10, 26–28]. In addition, patients who underwent total pancreatectomy died soon after due to the inability to manage hypoglycemia caused by the absence of glucagon in pancreatic diabetic patients. Since that time total pancreatectomy was abandoned. As an alternative, following type C Postoperative Pancreatic Fistula (POPF), the pancreatic remnant was simply disconnected and drained in an effort to preserve pancreatic hormonal function [5, 29]. Overall Survival in the current series was less than reported elsewhere [30]

and is likely due to a combination of the high perioperative mortality and lack of adjuvant therapy.

This study highlights important issues that are faced by the healthcare systems with the inability to centralize pancreatic resections. It is important that these data are made available and explained to patients so they can choose whether or not to take such radical surgery in their best interest especially when faced with almost ubiquitous short term morbidity but a minimal gain of life expectancy. Ultimately whether these outcomes, which are at odds with international centers of excellence, are seen as acceptable will be decided by the health providers and patients of Indonesia. It may be a catalyst for further enhancement of this type of model in an effort to further improve the outcomes. It should be remembered that the journey to centralization occurred over considerable time periods.

CONCLUSION

A hub and spoke model as a strategy for managing patients with peri-ampullary tumors can lead to an improvement in access and outcomes of PD resection. However further work is required if they are to achieve outcomes achieved by international high volume centers with centralization programs.

DECLARATIONS

Competing of Interest

The authors declare no competing interests.

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