DOI:10.1111/j.1477-2574.2011.00366.x

HPB

ORIGINAL ARTICLE

Staging laparoscopy for proximal pancreatic cancer in a magnetic resonance imaging-driven practice: what's it worth?

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Abstract

Background: Preoperative imaging is often inadequate in excluding unresectable pancreatic cancer. Accordingly, many groups employ staging laparoscopy (SL), although none have evaluated SL after preoperative magnetic resonance imaging (MRI). We performed a retrospective, indirect cost-effectiveness analysis of SL after MRI for pancreatic head lesions.

Methods: All MRI scans administered for proximal pancreatic cancer between 2004 and 2008 were reviewed and the clinical course of each patient determined. We queried our billing database to render average total costs for all inpatients with proximal pancreatic cancer who underwent pancreaticoduodenectomy, palliative bypass or an endoscopic stenting procedure. We then performed an indirect evaluation of the cost of routine SL.

Results: The average costs of hospitalization for patients undergoing pancreaticoduodenectomy, open palliative bypass and endoscopic palliation were: US$26 122.43, US$21 957.18 and US$11 304.00, respectively. The calculated cost of SL without laparotomy was US$2966.25 or US$1538.61 prior to laparotomy. The calculated cost of treating unresectable disease by outpatient laparoscopy followed by endoscopy was US$5943.17. Routine SL would increase our costs by US$76 967.46 (3.6%).

Conclusions: Staging laparoscopy becomes cost-effective by diverting unresectable patients from operative to endoscopic palliation. Given the paucity of missed metastases on MRI, the yield of SL is marginal and its cost-effectiveness is poor. Future studies should address the utility of SL by both examining this issue prospectively and investigating the cost-effectiveness of endoscopic vs. surgical palliation in a manner that takes account of survival and quality of life data.

Keywords

pancreatic adenocarcinoma, pancreaticoduodenectomy, staging laparoscopy, surgical palliation for pancreatic neoplasia, hepaticojejunostomy, gastrojejunostomy, cost-effectiveness

Received 8 April 2011; accepted 8 June 2011

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Introduction

Pancreatic cancer presents late in its natural history and thus those with resectable disease account for only 15–20% of all pancreatic cancer patients.[1–3] Some patients, however, present in time to undergo pancreaticoduodenectomy – the Whipple procedure – which offers the only potential cure for malignant lesions in or around the head of the pancreas. To determine resectability, surgeons often choose computed tomography (CT).[4,5] Unfortunately, CT is often inadequate in determining unresectability. Although the accuracy of CT has improved over time, as many as 10–48% of those deemed resectable on CT are taken to laparotomy for ultimately unresectable disease.[2,5–10] Some studies have explored the role of magnetic resonance imaging (MRI) in this setting, but these are few and increasingly dated.[4,11–14] Our group recently reported that, in our experience, MRI offers sensitivity of 100% for resectable disease and specificity of 73.2–78.9%.[15] Although a

This paper is based on a poster presentation given at the Society for Surgery of the Alimentary Tract and Pancreas Club Meeting, 1 May 2010, New Orleans, Louisiana.

number of patients were taken for laparotomy with what turned out to be unresectable disease, crucially only six (6.4%) had metastases, four (4.3%) of which were in the liver. An option advocated by many groups is to employ staging laparoscopy (SL). As our group does not regularly use SL in the management of pancreatic cancer, we performed a cost analysis of this procedure in the setting of our MRI-driven practice.

The strength of the case for SL is dependent on the yield of laparoscopy, which is inversely proportional to the quality of preoperative imaging and further constrained by the field of laparoscopic visualization. Many groups report high yields for SL, which finds metastases missed on CT in as many as 37% of cases.[2,16,17] The prevalence of CT-occult metastases has prompted several groups to support SL in a manner that presupposes its ability to detect tumours that are unseen on imaging.[18–20] This may give SL too much credit for four reasons. Firstly, even presuming a lack of human error, the camera may not capture deep hepatic and low omental metastases. Indeed, 7–35% of patients receiving SL have metastases that are later discovered at laparotomy.[6,9,17,21,22] Secondly, the potential yield of SL declines as the accuracy of preoperative imaging improves.[23] Thirdly, metastases are not the only reason to abort the Whipple procedure; SL is fundamentally limited in describing the extent of locoregional disease and its resectability in terms of vascular invasion. Finally, the unspoken premise of SL is that the patient with disease that is not amenable to pancreaticoduodenectomy *should* be spared a laparotomy. This is a value judgement based on physician and patient preference for operative vs. endoscopic palliation that is related, in part, to the surgical candidacy of the patient.

Justly, several groups have investigated the cost-effectiveness of SL. Despite their varied conclusions, on balance the data seem to indicate a small but positive cost : benefit ratio for SL after preoperative CT.[9,10,21,24–26] Herein, we present a study of the cost-effectiveness of SL in an MRI-driven practice.

Materials and methods

Assessing the MRI-driven practice

As described in a previous paper,[15] we undertook a retrospective review of all MRI scans administered for suspected pancreatic cancer at Emory University Hospital in the 4-year period between December 2004 and December 2008. Institutional review board approval was ascertained and a Microsoft Excel database was created to house data for all patients who were evaluated and treated for this prospective radiographic diagnosis. Patient, tumour and radiographic features were reviewed. Patient factors included age, sex and days between MRI and operation. Tumour factors included histopathological diagnosis and nodal status. Radiographic features included comments on the presence of metastases and the relationship of the tumour with the surrounding vasculature. In concert with the surgeons, our radiologists are able to give one of three diagnoses of unresectable, resectable or borderline disease. 'Unresectable' disease is defined as the presence of metastases or significant vascular invasion or encasement that is clearly not amenable to reconstructive surgery. In such cases, the diagnosis of pancreatic cancer is made by open biopsy during a palliative procedure, by CT-guided biopsy or by endoscopic brushings. These patients then undergo a palliative procedure, usually of endoscopic biliary with or without duodenal stenting. 'Resectable' disease denotes the absence of metastases and vascular involvement, and 'borderline' disease denotes tumours that significantly abut or compress otherwise patent vasculature (superior mesenteric vein, portal vein, hepatic artery, superior mesenteric artery). All radiological and pathological examinations were carried out at our institution. Histopathological diagnosis represents the reference standard.

Cost analysis

Using the experiences derived from the methods described above, we investigated the cost-effectiveness of incorporating SL for those patients deemed by radiography to have resectable or borderline resectable disease. Total costs were acquired from our financial department; these were accurate at April 2009. Total costs were abstracted directly from accounting ledgers and included the fixed costs of operations and variable direct costs (labour, supply, overheads), as well as standard indirect costs. We did not include any dollar values for which the sum was negotiable, such as professional fees. Accordingly, these costs are not charges; they represent the total cost incurred by the hospital for a given operation.

Average total costs for all patients treated for adenocarcinoma of the head of the pancreas in a 1-year period (April 2008 to April 2009) were assessed. This group of patients was further divided according to ICD-9 codes into those who received Whipple procedures (code 52.7), operative palliative bypasses (codes 51.37 and 44.39) and endoscopic palliative bypasses (codes 51.87 and 52.93), respectively. These values were derived from data on the hospitalizations of all patients who received care for pancreatic cancer delivered by all pancreatic surgeons at our centre. This includes patients in whom CT alone represented the only preoperative imaging. The costs of preoperative imaging were not included in the analysis as these would cancel out across the comparisons.

The costs of inpatient palliative endoscopy were those of the average patient hospitalized with a diagnosis of pancreatic adenocarcinoma and discovered to have metastatic disease on preoperative imaging. Many patients undergo endoscopy as outpatients; when these patients were considered in our study, we included only those costs generated in the endoscopy laboratory.

The costs of SL were identified using ICD-9 codes 54.2–54.29. They were further simplified as the itemized average costs of the materials, space and ancillary staff manpower. We assumed that the procedure required 30 min of operating room (OR) time and 30 min of anaesthetist time. We also assumed that the procedure would be converted to a laparotomy if the SL found no metastases. Accordingly, the costs of those materials routinely used in laparotomy and therefore already accounted for in the OR costs of the Whipple or palliative bypass groups were discounted (e.g. bispec-

tral index [BIS] monitoring, drapes, spontaneous compression devices, suction, Foley catheter, dermabond, post-anaesthesia care). If the SL was positive, the average costs of surgical pathology for patients receiving SL were included. The costs of perioperative laboratory testing and pharmacology were included explicitly in our consideration of outpatient laparoscopy, but were already included in the total cost of these services for hospitalized patients. This model presumes routine utilization (all patients); furthermore, it presumes no false negatives (no missed metastases on laparoscopy) and no intraoperative complications of laparoscopy (no bleeding or open conversions for unresectable disease).

The cost-effectiveness of laparoscopy was determined in the following fashion. First, the cost of the MRI-driven practice was assessed. Second, the cost of treating resectable disease by the Whipple procedure with laparoscopy was subtracted from that total to yield the cost of treating unresectable disease. Third, as the laparoscopy intervention both added cost and reduced the number of patients receiving operative bypasses by diverting them towards endoscopic palliation, a formula was constructed to determine the number of metastases required for laparoscopy to be cost-effective:

(cost of care for patients with unresectable disease in the MRI-driven practice) = (total number of patients with unresectable disease caused by metastases and vascular invasion − x)(cost of hospitalization with operative bypass and laparoscopy for unresectable disease) + x(cost of hospitalization with endoscopic palliation and laparoscopy for unresectable disease),

where x is the number of metastases found at laparoscopy. This calculation was repeated with the cost of outpatient management in place of that of inpatient endoscopic palliation.

Results

The outcomes of an MRI-driven practice

We identified 124 patients who received MRI for preoperative imaging of suspected pancreatic adenocarcinoma during the 4-year period under review. Thirty patients had unresectable disease and 94 patients were offered the Whipple procedure. Of the latter 94 patients, 41 had borderline resectable disease. Eight of the 94 patients declined an operation and 86 proceeded to the OR, where 65 received completed Whipple procedures, 20 received bypass operations and one received an exploratory laparotomy for benign disease (biopsy-proven pancreatitis). Whipple procedures were aborted in 11 of the 50 patients (22%) with resectable disease and 10 of the 36 (28%) patients with borderline resectable disease who proceeded to the OR (no significant difference). Of the 21 patients in whom Whipple procedures were aborted, 13 were found to have vascular invasion that was not amenable to reconstructive surgery, six had metastases that had been missed in preoperative imaging and two had benign pathology (chronic pancreatitis). Of the six patients with occult metastases, four patients demonstrated metastases in the liver (three on the liver surface, one in the posterior gallbladder wall) and two showed metastases in the omentum. The total patient group (n = 124) included 30 patients with radiographically unresectable disease secondary to MRI-detected metastases or vascular invasion that was not amenable to reconstructive surgery. Many of these patients underwent a procedure to palliate their symptoms which comprised the placement of plastic biliary stents with or without duodenal stents and was carried out in the gastroenterology laboratory by an experienced endoscopist.

Determining the costs of operative and non-operative management

Using ICD-9 codes, we found financial records for all patients hospitalized for the management of pancreatic adenocarcinoma between April 2008 and April 2009. These included all of our institution's hepatobiliary surgeons' patients, many of whom did not receive preoperative MRI. A review of these records yielded average costs for patients undergoing pancreaticoduodenectomy, operative bypass and endoscopic palliation; these are summarized in Table 1.

The average costs of endoscopic palliation were further divided into those for patients who received the procedure as outpatients and those for inpatients. We could not determine the proportion of patients receiving outpatient palliation. Therefore, in determining the cost of our practice, we included the cost of inpatient palliation only. In the time under study, 22.3% of patients received duodenal stenting and 33.3% required anaesthesia. The average costs incurred by patients receiving endoscopic palliation were US$2517.50/patient in the endoscopy suite and US$11 304.00/patient for an entire inpatient hospitalization. As the amount and type of preoperative imaging were variable, we subtracted the imaging costs. Incidentally, the cost of an MRI pancreas protocol was US$498.66, whereas that of a CT pancreas protocol was US$207.39.

The total cost of hospitalization for the average patient receiving a Whipple procedure was US$26 122.43. The total cost of an operative bypass was US$21 957.18 and the total cost of palliative stenting was US$11 304.00. Therefore, the cost of treating all patients in this MRI-driven practice series was US$2 159 058.73.

The costs of SL in an MRI-driven practice

The costs of SL are detailed in Table 2. Periprocedure laboratory and pharmacology costs, which are included in the total costs for hospitalized patients, are explicitly added to the costs of outpatient laparoscopy in Table 1. From these data we could then derive the cost of SL with (US$1538.61) or without (US$2966.25) laparotomy (Table 1).

We may then apply these costs to our case series. The cost of treating our patients with resectable disease by Whipple procedure is now US$27 661.04; the cost of treating unresectable disease by palliative double-bypass is now US$23 495.79, and the cost of treating metastatic disease with SL followed by palliative endos-

Table 1 Per patient costs of hospitalization for patients treated for pancreatic adenocarcinoma by a Whipple procedure, operative bypass or endoscopic palliation with stents. The cost of laparoscopy is added to each category. The cost of outpatient management of unresectable disease is constructed from an itemized list of costs, presuming no hospitalization after laparoscopy

Categories of cost	Whipple procedure, US$	Operative bypass, US$	Endoscopic palliation with stents, US$	Outpatient endoscopic palliation, US$
Hospital floor	11 631.63	6646.54	4679.76	N/A
OR or GI laboratory	4928.54	5309.02	2517.50	2517.50
Anaesthesia	1148.20	1551.00	219.12	219.12
Surgical pathology	614.27	385.80	See laparoscopy	See laparoscopy
Post-anaesthesia care unit	618.25	599.63	See laparoscopy	See laparoscopy
Blood bank	812.37	756.35	687.79	N/A
Chemistry laboratory	963.78	700.78	644.46	111.01
Microbiology laboratory	206.69	217.70	138.33	N/A
Pharmacology	3362.72	4153.53	2136.07	129.29
Respiratory	1212.08	991.02	N/A	N/A
Rehabilitation	623.90	645.81	280.97	N/A
Total	**26 122.43**	**21 957.18**	**11 304.00**	**3415.14**
Add laparoscopy	1538.61	1538.61	2966.25	2966.25
New total	**27 661.04**	**23 495.79**	**14 270.29**	**5943.17**

OR, operating room; GI, gastrointestinal; N/A, not applicable

Table 2 Costs of staging laparoscopy (SL) constructed from an itemized list of costs derived from financial records at our institution

Categories of cost	Costs of SL alone, US$	Add to costs of laparotomy?
Post-anaesthesia care	400.38	No
Trocars	415.04	Yes
Scissor tip	46.30	Yes
Warmer seals	4.50	Yes
Insufflation tubing	7.78	Yes
Bovie pieces	10.91	No
Harmonic scalpel	486.59	Yes
Bair hugger	13.77	No
Urine meter	22.49	No
Sterile drape set	44.88	No
Suction set	45.57	No
Staplers	14.24	No
Spontaneous compression device	24.65	No
Bispectral index monitor	24.01	No
Intravenous tubing and kit	40.68	No
Chlorhexidine	6.06	No
Dermabond 2 pack	62.90	No
Operating room time (30 min)	396.00	Yes
Anaesthetist (30 min)	182.40	Yes
Surgical pathology	717.10	No
Total	2966.25	1538.61

copy in the inpatient setting is US$14 270.29. The total cost of this practice is therefore US$2 236 026.19.

The costs of outpatient endoscopic palliation are further delineated in Table 2. By combining the costs of endoscopy with those of laparoscopy and its periprocedure, we can ascertain the costs of completely outpatient management. The total per patient cost of this strategy is US$5943.17.

Cost-effectiveness of SL

Staging laparoscopy changes the treatment strategy by redirecting patients with metastatic disease from the OR to the endoscopy suite. As endoscopic palliation is cheaper than operative management, the more patients who are switched to endoscopy, the cheaper the practice. However, as there is added cost to utilizing SL, its cost-effectiveness depends on its yield of metastases. In our series, 21 patients had unresectable disease at laparotomy and six of these had metastases. The cost of adding SL directly to the MRI-driven practice would increase the cost of inpatient management by US$76 967.46 (3.6%). If we add the cost of laparoscopy to that of all procedures, using the formula established earlier, the number of metastases found on laparoscopy that would render the procedure cost-effective is 14.30 in inpatient management and 7.54 in outpatient management.

Discussion

The goal of SL is to spare patients with inoperable disease from laparotomy. Similarly, the cost-effectiveness of SL depends on the proportion of patients redirected from the OR to the endoscopy suite and hopefully spared from hospitalization. This proportion

further depends on the number of metastases *discoverable* at laparotomy and thus the number of metastases missed on preoperative imaging. Beyond these considerations, the value of SL depends on surgeon and patient preference for operative vs. endoscopic palliation. Staging laparoscopy is only useful if endoscopic palliation is preferred over operative bypass in operative candidates. We found that, for SL to be cost-effective, the number of metastases detected at SL had to be greater than the number missed by preoperative MRI, even if metastatic disease was managed entirely on an outpatient basis. Given the paucity of MRI-occult metastases, in this cost-effectiveness analysis of SL in an MRI-driven practice, we find that SL is not a cost-effective procedure.

These results are strengthened by the advantages conferred upon SL by the study's five simplifying assumptions. It was assumed, first, that SL would detect all MRI-occult metastases; second, that SL would have no complications; third, that SL would not lengthen the hospitalization; fourthly, that SL could be undertaken entirely on an outpatient basis. Finally, we made our calculations on the assumption that all patients receiving palliative endoscopy in the non-SL group were inpatients, but that patients in the SL group received palliation as outpatients, adding considerable cost to the MRI-driven practice.

These assumptions were very kind to SL. Prior studies of SL show a 1.7–5.1% rate of minor complications, a 0.7–2.3% rate of major complications (requiring conversion to an open procedure or transfusion) and a 0.49% rate of death.[27,28] Although our methods capture the added hospital costs associated with open procedures (i.e. they represent the average total costs of hospitalization for all patients undergoing operative management), they do not capture those incidental costs that may be associated with SL. Furthermore, although this may reflect either the location of the deposit or operator error, 7–35% of patients receiving SL are found to have metastases that are discovered at laparotomy.[6,9,17,21,22]

For these reasons, SL has become controversial. Some practitioners endorse the practice for all patients with radiographically resectable disease[9,24] and some concede that its role is marginalized by good preoperative imaging.[21,23] Others propose that SL should be applied selectively in those patients with specific clinical features that have been shown retrospectively to predict the presence of occult metastases, such as extreme back pain, weight loss, elevated tumour markers and tumours located in the pancreatic tail.[5,10,25,29] None of these studies, however, have evaluated the utility of SL after a preoperative MRI and no study has addressed whether it is best to redirect patients who are candidates for intra-abdominal surgery from operative to endoscopic bypasses.

Our study has limitations. Firstly, this is a retrospective study and therefore subject to the limitations intrinsic to this sort of inquiry. Secondly, we did not study the clinical presentations of our patients and therefore we cannot comment on the use of a selective approach to SL. Thirdly, these costs are those of our institution alone and therefore limit the generalizability of our findings. Fourthly, our study represents an indirect evaluation of SL: the added cost of SL is a calculation based on the costs delineated in Table 2. However, the costs presented are generously low. Furthermore, by granting several advantages to SL in this indirect evaluation, including perfect yield, we have presented the upper limit of this practice's cost-effectiveness.

This study of our institution's experience with preoperative MRI in the treatment of pancreatic head lesions does not support the incorporation of routine SL. Further studies are needed to prospectively determine the *cost-effectiveness* of this procedure in both CT- and MRI-driven practices. Additionally, the *value* of SL ought to be determined by investigating the optimal approach to patients with inoperable disease using cost-effectiveness data that take account of data on mortality and quality of life after each procedure.

Conflicts of interest

None declared.

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