CASE REPORT

Improving outcomes for pancreatic cancer: radical surgery with patient-tailored, surgery-specific advanced haemodynamic monitoring

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SUMMARY

Pancreatic cancer has poor prognoses, with a median survival after diagnosis of less than 6 months. For some patients radical surgery remains the only chance of long-term cure. We report the successful outcome of a patient with pancreatic cancer and portal vein encasement that underwent a biliary bypass procedure and chemoradiotherapy. He was reassessed 8 months later where a complete resection of the pancreatic cancer was undertaken. The patient required a total pancreatectomy, splenectomy, subtotal gastrectomy and partial colectomy. Portal and superior mesenteric vein resection was performed, with reconstitution using the splenic vein as conduit with its draining inferior mesenteric vein. We report novel aspects of the surgical technique and describe our institution's patient-tailored, surgery-specific goal-directed strategy that was considered paramount for the successful perioperative outcome in this case.

BACKGROUND

Radical surgery for pancreatic cancer is a technically demanding procedure requiring highly specialised care. Even in experienced hands, perioperative morbidity rates are as high as 50%.¹ We describe the perioperative management of a patient with pancreatic cancer and portal vein encasement. We present this challenging case to reinforce the importance of seeking specialist advice when managing patients with pancreatic cancer and outline the unique aspects of the surgical technique that have not been previously reported. Furthermore, we overview the anaesthesia considerations that incorporated the use of Flotrac FloTrac/Vigileo (Edwards Lifesciences, Irvine, California, USA), a self-calibrating arterial pulse contour cardiac output monitoring system, that was paramount for the successful outcome of this case.

CASE PRESENTATION

A 64-year-old man was diagnosed with pancreatic cancer with portal vein encasement. His medical history included controlled insulin-dependent diabetes mellitus. The patient initially underwent a palliative biliary bypass procedure followed by chemoradiotherapy that consisted of four 3-week cycles of Gemcitabine in the first week supplemented by capecitabine in weeks 1 and 2. Week 3 of each cycle was a 'rest' week. Radiation therapy was administered 4 weeks subsequent to chemotherapy and consisted of 30 sessions over a 6-week period delivering a total dose of 54 Gy. Eight months later, the patient was referred to a university teaching

hospital with expertise in major hepatobiliary and pancreatic surgery, including liver transplantation, for an opinion regarding reoperative surgery and possible portal and superior mesenteric vein resection and reconstruction. Restaging imaging showed no evidence of metastatic disease. A 5–6 cm mass was noted in the head and uncinate process of the pancreas, with marked atrophy of the distal pancreas. After considered discussion with the patient and his family, together with a multidisciplinary team of hepatobiliary surgeons, anaesthesiologist, radiologist, oncologist and intensivists, a perioperative plan was created to provide comprehensive support and the best chance of successful outcome. After understanding the prognosis, accepting the risks and complications, the patient consented to radical surgical intervention.

TREATMENT

Anaesthesia

Prior to induction of anaesthesia, 300 µg of intrathecal morphine was injected into the L3/4 intrathecal space for postoperative analgesia. Induction of anaesthesia was achieved with fentanyl 3 µg/kg intravenously and propofol 3 mg/kg intravenously. After neuromuscular blockade with vecuronium 0.1 mg/kg intravenously, the trachea was intubated with a size 8.0 endotracheal tube. A 8 cm 20G arterial line (Leardale, Vygon, UK) was placed into the left radial artery and a triple lumen Presept oximetry central venous catheter (Edwards Lifesciences) with continuous central venous oxygen saturation (ScvO₂) monitoring was inserted into the right internal jugular vein using an ultrasound-guided technique. A 16G nasogastric tube was inserted. Dexamethasone phosphate 8 mg intravenously was administered for antiemetic prophylaxis. Anaesthesia was maintained with desflurane at inspired concentrations of 0.5–0.1 minimum alveolar concentration (MAC), with a fractional inspired oxygen air concentration of 0.5, and an infusion of remifentanyl 0.1–0.3 µg/kg/min intravenously. Mechanical ventilation maintained end-tidal pCO₂ between 35 and 40 mm Hg.

Monitoring

Monitoring included a five-lead continuous ECG, pulse oximetry, capnography, urine output and core body temperature. Intraoperative normothermia was maintained with warm fluids and a forced air warming device. A Flotrac device FloTrac/Vigileo (Edwards Lifesciences) was connected to the radial

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Figure 1 Advanced haemodynamic algorithm guided by FloTrac/Vigileo (Edwards Lifesciences, Irvine, California, USA) and continuous central venous oxygen saturation monitoring via a Precept oximetry central venous catheter (Edwards Lifesciences)

arterial line for advanced haemodynamic monitoring. Continuous ScvO₂ monitoring was measured via a Precept central venous catheter (Edwards Lifesciences) and systolic blood pressure was maintained within 20% of the preoperative value. Evidence of adequate end-organ perfusion was guided by serum lactate, base deficit, ScvO₂ > 70%, Bispectral index > 40 and normal ST-segments. Fluid intervention and use of inotropes and vasoconstrictors was guided by an advanced haemodynamic algorithm described in figure 1. An actrapid insulin infusion at 4–8 units/h was used to maintain blood glucose levels between 8 and 10 mmol/l. One hour prior to completion of surgery, tramadol 3 mg/kg intravenously and paracetamol 1 g intravenously was administered, and a continuous ketamine infusion started at 2 mg/h intravenously. Once the surgery was complete, fentanyl 150 µg intravenously was administered, and a continuous fentanyl infusion was started at 10 µg/h intravenously. The remifentanyl infusion and desflurane anaesthesia were discontinued and the patient was extubated within 6 min.

Surgery

The patient underwent complete resection of a 5 cm mass in the head of the pancreas that required a total pancreatectomy, splenectomy, subtotal gastrectomy and partial colectomy. A portal and superior mesenteric vein resection was performed, with reconstitution using the splenic vein as conduit with its draining inferior mesenteric vein. This technique has not been previously reported. An intraoperative photograph demonstrating the portal vein and superior mesenteric vein resection is presented in figure 2. The total operation time was 13 h. Blood loss was 300 ml. Intraoperatively, the patient received 1700 ml of fluid. The intraoperative haemodynamic and fluid variables are summarised in table 1.

Postoperative care

Postoperative care was guided by a surgery-specific fast-track surgical pathway used as part of our institutions enhanced recovery programme for major pancreatic surgery.² A summary of the

Fast Track protocol is outlined in table 2. The patient was discharged home on postoperative day 6.

OUTCOME AND FOLLOW-UP

The patient made an uncomplicated recovery and remains disease free at 1-year follow-up.

DISCUSSION

Pancreatic cancer has one of the poorest prognoses, with a median survival after diagnosis of 4.5 months. Pancreatic cancer often presents insidiously with the majority of patients not diagnosed until they have advanced or metastatic disease. Symptoms include weight loss, back pain and jaundice. Chemotherapy extends survival by less than 2 months and approximately 18% of those treated with chemotherapy survive beyond 1 year. Complete surgical resection therefore remains the only possibility of cure; however, only 10% of patients undergo curative surgery. Even with complete surgical resection the 5-year overall survival rate is quoted as 5–7% compared with a median survival of 3–11 months for unresected cancer. For some patients, radical surgery remains the only chance of long-term cure with higher survival rates (between 6.8% and 17%) reported in those selected for surgery.^{3 4}

In addition to the unique surgical aspects of this case, we consider the intraoperative haemodynamic goal directed algorithm utilised (figure 1) to be paramount for the successful outcome of this patient. Use of intraoperative fluid management technologies enables closer monitoring and management of patients' hydration status during high-risk surgery. Evidence shows that the use of this technology can facilitate improved outcomes for patients due to reduction in postoperative complications and length of stay with ultimate benefits for the health economy. This technology has been endorsed by the National Health Service⁵ and is standard of care for all patients undergoing complex and prolonged hepatobiliary and pancreatic surgery in our institution. Previous research by our group has demonstrated that liberal fluid intervention in

Figure 2 (A) Operative photo prior to portal vein and superior mesenteric vein (SMV) resection. The splenic vein has been skeletonised with the body and tail of the pancreas removed. The inferior mesenteric vein (IMV) drains into the splenic vein. The superior mesenteric artery (SMA) can be seen with the uncinate process separated from it. (B) Reconstructive photo shown with the splenic vein rotated and anastomosed to the portal vein superiorly and SMV inferiorly, with the drainage of the IMV maintained.

patients undergoing major pancreatic surgery is associated with a major complication rate of 50%.¹ Inappropriate infusions of vaso-pressor agents in the setting of uncorrected hypovolaemia can lead to tissue hypoperfusion, organ dysfunction and ischaemia.⁶ This impairment may not be reliably revealed by alterations in conventional haemodynamic indices such as heart rate, urine output, central venous pressure or blood pressure. Numerous investigative studies in a spectrum of patient populations (cardiovascular surgery, trauma, sepsis and other critical illnesses) have challenged the

notion that these indicators accurately predict volume status.^{7–10} By using the flow-related parameters such as stroke volume, cardiac output and markers of fluid responsiveness such as stroke volume variation (SVV), one is able to precisely infer where the patient is on their Frank Starling relationship, and thus, optimise oxygen delivery.

There is growing evidence that perioperative goal-directed therapy based on flow-related haemodynamic parameters leads to reduction in complications and length of stay, and we

Table 1 Perioperative haemodynamic and fluid variables

	Intraoperative	ICU POD 0	POD 1	POD 2	POD 3	POD 4	POD 5	POD 6
Intraoperative								
Duration of surgery	13 h							
Blood loss (ml)	300	50 via drain	0	0	0	0	0	
Inotrope use	497	76	0	0	0	0	0	
Norepinephrine (µg)								
Total fluid intake (ml)	1700	1500	2300	1400	1550	1350	NR	
PlasmaLyte	1000	1500	2000	1000	1000	0	0	
Voluven	500	500	0	0	0	0	0	
20% Albumen	200	0	0	0	0	0	0	
Blood transfusion	0	0	0	0	0	0	0	
Oral fluids	NBM	Ice	300	400	550	700	ND	
Diet	Nil	Nil	Nil	Soft diet	Soft diet	Light meals	Full WD	
Total fluid balance (ml)	1295	450	1005	–203	460	700	ND	
Lowest temperature (°C)	35.5	35.9	36.0	36.2	36.1	36.4	36.5	
Lowest SBP (mm Hg)	93	98	90	95	103	110	112	
Lowest DBP (mm Hg)	46	46	48	50	51	54	54	
Highest SBP (mm Hg)	146	150	156	158	143	124	118	
Highest DBP (mm Hg)	89	95	99	100	89	89	89	
Lowest Hb (g/dl)	103	92	88	90	91	89	90	
Highest lactate (mmol)	2.3	2.4	1.9	NR	NR	NR	NR	
Lowest HCO ₃ (mmol)	23.7	22.9	23	24.2	26.1	25.8	NR	

DBP, diastolic blood pressure; Hb, haemoglobin; ICU, intensive care unit; NBM, nil by mouth; NR, not recorded; POD, postoperative day; SBP, systolic blood pressure; WD, ward diet.

Table 2 Surgery specific enhanced recovery pathway protocol for complex pancreatic surgery

Before surgery	<ul style="list-style-type: none"> ▶ Multidisciplinary evaluation ▶ Optimisation of comorbidities ▶ Informed consent ▶ Routine biochemistry, haematology, coagulation tests, CXR ▶ ECG ▶ Baseline weight
Anaesthesia	<ul style="list-style-type: none"> ▶ Intrathecal morphine for postoperative analgesia ▶ Insertion of Flotrac/Vigileo haemodynamic monitoring device ▶ Haemodynamic optimisation (see figure 1) ▶ Prophylactic antibiotics ▶ Supplementation of magnesium and potassium ▶ Thrombo-embolic prophylaxis ▶ Nasogastric tube ▶ Maintenance of anaesthesia and analgesia: remifentanyl and desflurane <p>One hour prior to completion of surgery:</p> <ul style="list-style-type: none"> ▶ The start of fentanyl intravenous infusion at 10 µg/h ▶ The start of ketamine intravenous infusion at 2 mg/h ▶ Paracetamol 1 g intravenously, tramadol 3 mg/kg intravenously ▶ Consider non-steroidal anti-inflammatory
Recovery and day of surgery	<p>Analgesia</p> <ul style="list-style-type: none"> ▶ PCA fentanyl (20 µg/bolus, 5 min lockout) ▶ Continue fentanyl intravenous infusion (10 µg/h) ▶ Continue ketamine intravenous infusion (2 mg/h) ▶ Strict four times a day paracetamol 1 g IVI ▶ prn tramadol, low-dose ketamine infusion (2 mg/h) <p>Fluid intervention</p> <ul style="list-style-type: none"> ▶ 12 hourly balanced crystalloid maintenance fluid therapy ▶ 4% albumex 250 ml prn for filling <p>Other</p> <ul style="list-style-type: none"> ▶ Strict thrice a day metoclopramide 15 mg intravenously ▶ Potassium and magnesium supplementation ▶ Continue antibiotics for 24 h ▶ Pantoprazole 40 mg intravenously ▶ Thromboembolic prophylaxis
Day 1	<p>Analgnesia</p> <ul style="list-style-type: none"> ▶ Stop fentanyl background infusion ▶ Continue PCA fentanyl (20 µg/bolus, 5 min lockout) ▶ Continue ketamine infusion (2 mg/h) ▶ Strict four times a day paracetamol ▶ prn tramadol <p>Fluid intervention</p> <ul style="list-style-type: none"> ▶ Reduce maintenance fluid therapy to 83 ml/h ▶ 4% albumex 250 ml prn for filling <p>Other</p> <ul style="list-style-type: none"> ▶ Daily weight ▶ Strict three times a day metoclopramide 15 mg intravenously ▶ Potassium and magnesium supplementation ▶ Continue antibiotics for 24 h ▶ Pantoprazole 40 mg intravenously ▶ Remove nasogastric tube unless output >300 ml/day ▶ Physiotherapy: early mobilisation three times a day ▶ Thromboembolic prophylaxis
Day 2	<p>Analgnesia</p> <ul style="list-style-type: none"> ▶ Continue PCA fentanyl (20 µg/bolus, 5 min lockout) ▶ Stop ketamine infusion ▶ Strict four times a day paracetamol ▶ prn tramadol <p>Fluid intervention</p> <ul style="list-style-type: none"> ▶ Aim for neutral fluid balance ▶ Reduce maintenance fluid therapy to 42 ml/h ▶ To start oral sips ▶ 4% albumex 250 ml prn for filling

Other

- ▶ Daily weight
- ▶ Strict three times a day metoclopramide 15 mg intravenously
- ▶ Potassium and magnesium supplementation
- ▶ Pantoprazole 40 mg intravenously
- ▶ Use of diuretic if positive fluid balance (furosemide 10–20 mg)
- ▶ Strict metoclopramide 15 mg intravenous three times a day
- ▶ Pantoprazole 40 mg intravenously
- ▶ Thromboembolic prophylaxis
- ▶ Removal of central venous catheter
- ▶ Removal of urinary catheter
- ▶ Physiotherapy: early mobilisation three times a day

Day 3

Analgnesia

- ▶ Stop fentanyl PCA
- ▶ Start oxycodone (IR) 10 mg orally 4 hourly
- ▶ Strict four times a day paracetamol
- ▶ prn tramadol

Fluid intervention

- ▶ Aim for neutral fluid balance
- ▶ Use of diuretic if positive fluid balance (furosemide 10–20 mg)
- ▶ Stop intravenous maintenance fluids
- ▶ Start oral sips
- ▶ 4% albumex 250 ml prn for filling

Other

- ▶ Daily weight
- ▶ Strict three times a day metoclopramide 15 mg IVI
- ▶ Potassium and magnesium supplementation
- ▶ Pantoprazole 40 mg intravenously
- ▶ Thromboembolic prophylaxis
- ▶ Removal of central venous catheter
- ▶ Removal of urinary catheter
- ▶ Physiotherapy: early mobilisation TDS
- ▶ Coloxyl 100 mg orally twice a day

Day 4

Fluid intervention

- ▶ Advancing from soft diet to small meal
- ▶ Daily weight
- ▶ Use of diuretic if positive fluid balance (furosemide 10–20 mg)

Analgnesia

- ▶ Continue oral oxycodone IR
- ▶ prn paracetamol and tramadol

Other

- ▶ Stop metoclopramide
- ▶ Thromboembolic prophylaxis
- ▶ Physiotherapy therapy
- ▶ Coloxyl 100 mg orally twice a day
- ▶ Start creon 25 000 units orally with meals (2 tablets if total pancreatectomy with main meals and 1 with snacks)

Day 5

Fluid intervention

- ▶ Advance diet
- ▶ Use of diuretic if positive fluid balance (furosemide 10–20 mg)

Analgnesia

- ▶ Continue oral oxycodone IR
- ▶ prn paracetamol and tramadol
- ▶ Thromboembolic prophylaxis
- ▶ Consider removing wound drains

Day 6

- ▶ Full ward diet
- ▶ Daily weight
- ▶ Continue oral oxycodone IR prn or tramadol
- ▶ prn paracetamol

Day 7

- ▶ Discharge

CXR, chest x-ray; IVI, intravenous infusion; IR, intermediate release; PCA, patient controlled analgesia.

strongly advocate its use in this regard. SSV is a frequently used 'target' to optimise the preload required to obtain a maximal stroke volume or cardiac output in accordance with the Frank Starling law of the heart. Therefore, SVV can be used to predict whether cardiac output will increase in response to a fluid challenge. A SVV of >10% suggests that the patient is 'fluid responsive' and further fluid challenges of 200–250 ml of colloid are frequently advocated and justified. In the case described, due to the complexity and prolonged duration of the surgery, we accepted a target SVV threshold of 20% which we considered to be safe in the setting of a normal cardiac index and ScVO₂. We think that this fluid minimisation strategy contributed to the favourable outcome of this patient. This case illustrates the concept of patient-tailored, surgery-specific haemodynamic monitoring and adds to a growing body of evidence for goal-directed fluid management therapy.

Finally, patients diagnosed with pancreatic cancer should always seek specialist opinion regarding treatment options. A multidisciplinary team will best serve patients and their families, where surgeons, anaesthesiologists, oncologists, radiologists and others, work together to create a strategy that provides comprehensive support and the best chance of successful outcome.¹¹

Learning points

- ▶ Pancreatic cancer has poor prognoses.
- ▶ The diagnosis is often made late in the disease course where the patient presents with weight loss, pain and jaundice.
- ▶ Patients diagnosed with pancreatic cancer are encouraged to seek specialist opinion regarding treatment options.
- ▶ The only curable treatment is surgical resection and postoperative chemotherapy may lower the chances of cancer recurrence.
- ▶ Patient-tailored, surgery-specific advanced haemodynamic monitoring may minimise unnecessary intraoperative fluid intervention and rationalise use of inotropes and vasopressors.
- ▶ Many organisations exist to help provide information and support for patients and families fighting pancreatic cancer.

Contributors LW principle anaesthetist was involved in management of the case and in addition, reviewing all literature, photographing clinical pictures, obtaining patient consent and writing of the manuscript. NH hepatic and pancreatic surgeon was involved in performing case and in addition, writing of the manuscript. MN hepatic and pancreatic surgeon was involved in performing case and in addition, collation of all images, data collection from medical records and writing of the manuscript. All authors have read and approved the submission manuscript.

Competing interests LW and MN serve on the board of PANCARE foundation, a not-for-profit organisation to increase public awareness and improve treatment outcomes of patients with pancreatic, liver, biliary and foregut cancer through research, education and support. (<http://www.pancare.org>).

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