Implementation and Evaluation of a Clinical Pathway for Pancreaticoduodenectomy Procedures: a Prospective Cohort Study

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Abstract

Introduction Medical and nursing protocols in perioperative care for pancreaticoduodenectomy are mainly mono-disciplinary, limiting their integration and transparency in a continuous health care system. The aims of this study were to evaluate adherence to a multidisciplinary clinical pathway for all pancreaticoduodenectomy patients during their entire hospital stay and to determine if the use of this clinical pathway is associated with beneficial effects on clinical endpoints.

Materials and Methods A prospective cohort study was conducted in 95 pancreaticoduodenectomy patients treated according to a clinical pathway, including a variance report, compared to a historical control group (n = 52) with a traditional treatment regime.

Results Process evaluation of the clinical pathway group revealed that protocol adherence throughout all units was above 80%. Major complications according to Clavien-Dindo classification grade ≥3 decreased from 27 to 13%; p = 0.02. Hospital length of stay was significantly shorter in the clinical pathway group, median 10 days [IQR 8–15], compared with the control group, median 13 days [IQR 10–18]; p = 0.02.

Conclusion The use of a clinical pathway in pancreaticoduodenectomy patients was associated with high protocol adherence, improved outcome and shorter hospital length of stay. Variance report analysis and protocol adherence with a Prepare-Act-Reflect Cycle are essential in surveillance of outcome.

Keywords Pancreaticoduodenectomy · Clinical pathway · Protocol adherence · Perioperative care

Introduction

Pancreaticoduodenectomy for pancreas tumours and periampullary tumours is considered high-risk surgery and is associated with high morbidity (30–70%) and a mortality of 1–5% in specialized centres.1, 2 Centralization of pancreas surgery and advances in surgical techniques resulted in more patients being operated for advanced-staged tumours.3, 4 Patients with more comorbidity receiving pre-operative chemotherapy and/or vascular reconstructions in advanced disease, need more complex perioperative care. Currently this is facilitated by multiple guidelines and medical and nursing protocols. This complexity demands an overall multidisciplinary approach and clear communication.

Different departments are involved in the treatment during the patients’ journey through the surgical ward, operation theatre, post-anesthesia care unit (PACU) and intensive care unit (ICU). However, large differences in the actual use of these protocols are present between the different units and medical and nursing staff members.5, 6 Moreover, while multidisciplinary teamwork for these patients is essential, the development and implementation of a clinical pathway (CP) involve many aspects of the total patient care and should therefore be multidisciplinary by doctors and nurses as well.
A CP may facilitate the care for this group of high-risk surgery patients by unifying different protocols into one multidisciplinary protocol for all units during the hospital stay of the patients. This may result in an increased protocol adherence, less morbidity and improved outcome. Key elements of a CP are guidelines, evidence-based clinical protocols and best practice rules, together with a coordinated sequence of activities of the multidisciplinary team. Registration, monitoring and evaluation of adherences, variances and outcomes are part of a CP and can be part of a process-driven pathway. A multidisciplinary CP has therefore many evaluation moments and scheduled actions. To keep the patient on the ‘pathway’, the CP mandates a registered response of the nurse or doctor if results are outside the range of the prescribed boundaries.

Many CPs have been developed for high volume with low-risk and with average-risk health care procedures in order to reduce complications. The post-operative phase of the patient spent in the ICU or PACU, however, is a seldom part of a CP. A CP including the PACU/ICU stay mandates an hourly care plan during the post-operative stay in the ICU/PACU. Many standardized care plans related to a pancreaticoduodenectomy have been published, focussing on the use of an enhanced recovery program after surgery (ERAS) with elements like early mobilization, early enteral feeding, pain treatment and reduction of iv fluid administrations to shorten the length of hospital stay. In these care plans, a reduction of hospital length of stay (LOS), morbidity or mortality was not always observed. Crucially, the ICU period of these patients was not integrated in these protocols.

The aim of this study was first to determine the feasibility to develop and implement a multidisciplinary CP including a variance report for all pancreaticoduodenectomy patients during their entire hospital stay and second to determine if the use of this CP is associated with an improvement of patient’s morbidity and outcome.

**Development of the CP**

The development of the multidisciplinary CP for pancreaticoduodenectomy was a multistep procedure with the use of lessons learned from the development and implementation of the cardiac and oesophageal CPs, previously developed in Radboudumc, and started in 2013. The first step was redefining and searching for evidence underneath the surgical, anaesthesiology and ICU protocols in the perioperative period. This was a multidisciplinary procedure, undertaken by the physician assistants, senior nurses, ‘key’ nurses and medical staff. Instead of a traditional ‘day-to-day-care’ plan for the surgical ward, an ‘hour-to-hour’ care plan had to be developed, including the PACU and ICU care. It was important to identify potential barriers and facilitators in these settings, in order to tailor the implementation strategy. An evidence-based implementation strategy according to Grol was used.

Second, a unique variance report (‘Radboud variance report’; Appendix 1) had to be incorporated and developed together with the CP. This Radboud model of variance report enables nurses, physician assistants and young residents to execute predefined actions in accordance with and within the preset boundaries of a variance protocol, without having to wait for approval of the responsible physician first (Dutch law and order for health care professionals BWBR0006251 chapter IV, article 35).

Until 2012, a surgical pancreas matrix for (peri)operative care was used at the surgical ward. The historical control group was treated according to this matrix including the surgical medical and nursing protocols without the variance report. In the PACU and ICU, these patients were treated according to different PACU and ICU protocols. This pancreas matrix was used as backbone for further multidisciplinary development of the CP. As part of the development and implementation strategy, a small group of key nurses responsible for other CPs reflected on the concepts of the pancreas CP and variance report as part of a Prepare-Act-Reflect (PAR) Cycle.

The pancreas CP had to be a continuum from admission to discharge from the hospital. Essential elements included restrictive intra-operative fluid use, strict pain control, early mobilization, early drain and tube removal and early enteral feeding. Post-operatively, early warning scores (EWS) are measured at least once during every 8-h shift or more frequent, whenever indicated by the nurses, with strict directives for action by nurses according to the variance report.

Patients with a malnutrition universal screening tool (MUST) score above 2 need an active feeding intervention according to the quality system of health care in the Netherlands. We decided that patients with a MUST above 2 should start with total parenteral nutrition (TPN) within 24 h after surgery. Publications on
calorie deficit and enteral feeding or TPN after surgery in ICU patients often do not take into account malnutrition and MUST score >2. Our protocol prescribes that if the gastric tube can be removed, the patients need to start with oral/enteral feeding, and TPN needs to stop as soon as the oral intake of the patients is above 1000 kcal. TPN should be started on day 3 if patients had a MUST score of 1 and enteral feeding had not been started on day 3. All patients with a gastroparesis without signs of sepsis or ileus on day 7 will be given a naso-jejunal tube by the gastroenterologist through the gastrojejunostomy and start enteral feeding. In contrast to ERAS-based protocols, deviations from the CP had to lead into prompt actions according to the variance report.

Implementation of the CP

After informative meetings for medical and nursing staffs, including reflections on the positive aspects of previous CPs, bedside training started on the surgical ward and PACU/ICU in 2014. Implementation of the pancreas CP would introduce an essential change in daily practice for most nurses, physician assistants and medical staff. The first step in teaching was getting acquainted to the CP vision that would result in one continuous multidisciplinary protocol. In nursing and medical staff meetings, updates of the project were discussed, and feedback was welcomed by the CP developers. During this teaching period, especially new PACU-specific aspects arose for the pancreas CP, including new variance report criteria, and as an interactive process of PAR cycles, these criteria were incorporated in the pancreas CP during the development. In this try-out period, feedback was asked and given every 4 weeks during the multidisciplinary team meetings of the project. After 4 months of teaching and try-out period, it was concluded that it was feasible and safe to use the pancreas CP with the Radboud model variance report for patients during their entire clinical stay, including the PACU/ICU. With the completion of this implementation step, the pancreas CP was considered being implemented and our study on the use of the CP and variance report for all pancreatectoduodenectomy patients started on the first of September 2014, 18 months after the start of the development of the CP, including many PAR cycles. Patients treated for other pancreas procedures than pancreaticoduodenectomy were considered candidates to have the benefits of the pancreas CP during their stay in PACU/ICU and ward, but were not included in this study. Protocol adherence was measured per pathway action. We considered protocol adherence if a deviation from the CP resulted in the correct action, according to the CP, or if no action was needed and no action was started. No protocol adherence was defined as wrong actions or no actions if actions were needed. Deviations from the CP had to be described in the variance report or patient record.

Design

This is a pre-post design study. After the implementation of the pancreas CP, patients treated according to the CP were compared with a historical control group of patients treated with standard perioperative care for pancreatectoduodenectomy according to the original pancreas matrix and multidisciplinary protocols and operated on between 2009 and 2012.

End Points

Primary endpoint was to determine the feasibility and safety, including incidence of post-operative complications, according to Clavien-Dindo classification, of the use the CP. Secondary endpoints were in length of stay (LOS) in-hospital, post-operative fluid balance, gastroparesis, protocol adherence to mobilization, drain removal, radiologic and surgical re-interventions, ICU readmission, hospital readmission and mortality rate.

Statistics

Continuous variables were described as median and interquartile range [IQR] and tested with the Mann-Whitney U test. Differences in dichotomous variables were analyzed using the chi-squared test. Due to the exploratory nature of this study, and to increase the sensitivity to detect differences between groups, no correction for multiple testing was performed. With our convenience sample size of 95 patients in the CP group and 52 patients in the control group, our study had 80% power to demonstrate a 7% absolute reduction of post-operative complications. All statistical analyses were performed using SPSS version 20.01 for Windows (IBM, SPSS statistics, Chicago, IL, USA).

Results

Development Results of the CP

Nurses, physiotherapists, dieticians and medical staff specialized in pancreas surgery contributed to the development of the pancreas CP and the variance report. This resulted in a set-up of clear and safe boundaries in taking clinical treatment decisions and an upscaling system to consultation with a key nurse or senior staff members, if actions according to the variance report did not seem right.

First, the pancreas CP for medical and nursing decisions was written according to existing evidence-based protocols, best practices and guidelines. Finally, a multidisciplinary variance report was incorporated (Appendix Table 4: summary of the differences between CP and control surgery and Appendices 2 and 3: variance report).

For the analysis of the developmental process, we evaluated barriers and facilitators for protocol adherence. For this,
Implementation Results of the CP

First, the medical aspects of the CP were implemented on the ward followed by the nursing aspects. Because of the lack of experience with CPs, the care providers working on the PACU received more time for training and bedside teaching and started later with implementation. Key nurses at the surgical ward gave guidance and were partner for the key nurses of the PACU.

Evaluation after the implementation process was performed every 2 months during the first 6 months and after this period whenever needed. These evaluations resulted mostly in questions or new ideas for a change in the CP from the units or when less compliance was observed. The variance report was an important tool for evaluating compliance. When compliance of one of the CP domains was below 80%, feedback was given by the key nurse or surgeon through focussed teaching sessions for nurses and residents.

After a period of 18 months, the pancreas CP was implemented and evaluation of protocol adherence was 80% for PACU/ICU periods and 60% for the surgical ward. The latter was mainly influenced by a low compliance to drain removal (<50%). According to the pancreas CP, drain removal was allowed if amylase level in the drain was below 500 U/l and volume below 200 ml/day. Deviations turned out to be primarily a system problem of postponing drain removal during weekends. After recognition of this system problem, an active policy started and protocol adherence on this item improved to above 80%.

Following the implementation, in September 2014, the outcome study of the pancreas CP was started (Fig. 1 implementation flowchart).

Clinical Outcomes

Between September 2014 and September 2016, in total, 95 elective consecutive pancreaticoduodenectomy patients were treated within the pancreas CP. Semi-acute pancreaticoduodenectomies (for bleeding tumours) and other types of resections (e.g. total pancreatic resections or pancreaticoduodenectomies with resection of a secondary colorectal tumour) were no part of the study. A cohort of 52 consecutive elective pancreaticoduodenectomy patients treated before the CP implementation period between 2009 and 2012 was identified as historical control group. Their perioperative treatment had been according to the underlying matrix protocol that was used as base for the development of the CP. Three surgeons in the pre-CP period operated on the pancreaticoduodenectomy patients. Results between these surgeons did not differ, and perioperative care was regulated by protocols. These surgeons were also responsible for pancreas surgery in the CP period.

Baseline characteristics between the two groups were not significantly different, apart from a higher number of CP patients receiving portal vein resection or celiac trunk/superior mesenteric artery (SMA) vessel exploration (Table 1).

Intra-operative Data

The median intra-operative amount of fluids administered was 3900 ml [IQR 3000–4600] in the CP patients versus 5200 ml [IQR 4000–6000] in the control group (p < 0.001). Postoperative fluid balance and fluid balance on day 1 postoperative were also significantly lower in the CP group versus the control group (p < 0.001; Table 2). Although more portal vein resections and celiac trunk and explorations along the SMA were performed, blood loss was less in the CP patients: 755 ml [IQR 500–1100] versus 1303 ml [IQR 656–2402] (p < 0.001, Table 2).

Post-operative Data

Adherence of pain and hemodynamic interventions according to the variance report was 100% at the PACU/ICU, and a step-up approach regarding pain control was adequately used according to CP protocol. Hemodynamic interventions in accordance with the variance report were not needed and not started in 17% of the CP patients, and 57% of the CP patients needed an extra hemodynamic intervention which was subsequently started according to the CP protocol. In total, 26% of the patients were treated with vaspressors on arrival in the PACU/ICU, which could be reduced during their stay. Significantly more CP patients were swing mobilized within 24 h compared with the control group, respectively, 83 versus 19%, p = 0.001. Especially poor pain control and patients’ feelings of weakness, early after the operation, were recorded as reasons not to start swing or mobilization at the surgical ward. Trigger for complications was the EWS; in 32% of the patients in the CP group, the EWS was above 3. Interventions on a high EWS were adequate and according to the variance report >95% of the patients.

Considering clinical outcome, major complications according to the Clavien-Dindo classification grade 3 or more occurred less frequently (13 vs 27%, p = 0.02) in the CP group, compared to the control group. One patient had a Clavien-Dindo 4b complication as a result of pancreatic leakage complicated by sepsis with EWS >6 on day 7 and hemorrhagic bleeding on day 14 in the CP group. This complication was successfully treated by radiologic coiling of the gastroduodenal artery and splenic artery.
Less patients suffered from gastroparesis grades B and C in the CP group compared to the control group, 9 versus 62%, \( p < 0.001 \), as were radiologic interventions: 11 versus 27%, \( p = 0.04 \). In the control group, the gastric tube was not removed when production was reduced but was left in place and blocked and could be removed if after measurement of retention after 8 and 16 h, it was less than 100 ml per 8 h. Pancreatic leakage and chylus leakage, readmission to ICU and readmission to hospital did not significantly differ between the CP group and control group. Median times to drain removal were also not influenced. The mortality rate was low and not different between groups (Table 3).

### Discussion

This study illustrates that development of a CP for pancreaticoduodenectomy is an iterative multidisciplinary process, starting with a dynamic protocol with improvements through PAR cycle evaluation and change moments. Implementation of the pancreas CP in all units involved in the entire (peri-) operative process (OR, PACU/ICU/surgical ward) took 18 months. Process evaluation of the prospective CP group revealed that protocol adherence was successfully achieved in >80% for most of the criteria throughout the clinical stay. Comparison of both cohort groups on main clinical outcomes showed that major complications according to the Clavien-

### Table 1 Baseline characteristics of pancreas CP and control groups of pancreaticoduodenectomy

| Clinical pathway, \( N = 95 \) | Control, \( N = 52 \) | \( P \) |
|---------------------------------|-----------------|------|
| Age, median (IQR)              | 66 (57–72)      | 66 (58–72) | 0.98 |
| Male, \( n \) (%)               | 56 (58.9)       | 35 (67.3)  | 0.26 |
| Stent/(PTC) percutaneous drainage, \( n \) (%) | 59 (61.5) | 28 (53.8)  | 0.34 |
| Pulmonary comorbidity, \( n \) (%) | 13 (13.7)   | 4 (7.7)     | 0.52 |
| Cardial comorbidity, \( n \) (%) | 13 (13.7)     | 10 (19.2)   | 0.62 |
| Vascular comorbidity, \( n \) (%) | 29 (30.5)    | 16 (30.8)   | 0.80 |
| Diabetes, \( n \) (%)           | 21 (22.1)       | 16 (31.4)   | 0.4  |
| Preoperative chemotherapy, \( n \) (%) | 4 (4.2)      | 0           |     |
| Portal vein resection, \( n \) (%) | 20 (21.1)    | 1 (1.9)     | <0.001 |
| Celiac trunk/SMA exploration, \( n \) (%) | 6 (6.3)     | 0           |     |

IQR first and third interquartile range, PTC percutaneous transhepatic cholangiography, SMA superior mesenteric artery
Table 2  Intra-operative results of pancreas CP and control groups of pancreaticoduodenectomy

| Fluid and vasopressor management                                      | Clinical pathway, N = 95 | Control, N = 52 | P  |
|-----------------------------------------------------------------------|--------------------------|----------------|----|
| Intra-operative fluids (ml), median (IQR)                             | 3900 (3000–4600)         | 5200 (4000–6000) | <0.001 |
| Fluid balance, at the end of the procedure, median (IQR)              | 405 (–107 to 833)        | 1926 (1253–2818) | <0.001 |
| Intra-operative blood loss, median (IQR)                             | 755 (500–1100)           | 1303 (656–2402)  | <0.001 |
| Intra-operative vasopressor use, n (%)                               | 94 (99)                  | 48 (92)         | 0.22 |

Dindo classification grade 3 or more and hospital LOS in the CP group were significantly lower compared to the control group. In addition, implementation of the CP was associated with a reduction of gastroparesis, an improved post-operative fluid balance, and patients in the CP group were more likely to receive early mobilization and adequate actions on EWS above 3. These data illustrate that implementation of a CP in this specific group of patients is feasible, safe and likely to be beneficial for the patient.

Analyzing reasons not to follow the variance report was part of this study. Human factors were often reasons for deviation from the report, for example, insecurity of young professionals on decisions leading to postponing gastric tube removal. The prevention of gastroparesis is part of a very active PAR cycle in the CP. Nurses, young doctors and patients want to prevent discomfort for the awake patient while repositioning the tube, even if early removal is according to protocol. The action was a team reflection on the discomfort of a needless gastric tube for too long and, as a result, delay in starting early oral nutrition and well-being.

Postponing early mobilization because of patients’ pain or weakness did occur. In all situations, the iterative process of repeated and specific education was important to explain the reasons behind the CP and guidance.

Considering the diverse landscape of CPs and surgical care plans, it is difficult to compare the different studies. In studies, related to implementation of CPs, not all hospital wards involved in the clinical process (like PACU/ICU) were included, which negatively influences the continuous care process for the patient. Also different treatment regimes make reliable comparison and evaluation of different CPs difficult. Regarding the available studies, we found only studies not covering the whole clinical stay, excluding parts of the post-operative period. In these studies usually some specific aspects like ERAS, drain and gastric tube removal were addressed. A standardized care plan for pancreaticoduodenectomy patients was retrospectively studied in another study focussing on predictors of LOS in-hospital. Specific ERAS pathways, without PACU/ICU periods involved, focussed on in-hospital LOS, outcome mortality and morbidity. While these were unchanged, measurement of protocol adherence was not part of the study. Braga et al. evaluated the compliance to the enhanced recovery protocol and concluded that patients with low compliance had a higher incidence of complications.

Our results are in pursuance of previous studies that showed that a CP or standardized care plan for pancreaticoduodenectomy patients resulted in an earlier start of solid enteral feeding and a shorter hospital LOS and less readmissions. Importantly, protocol adherence to predefined targets has not been part of these studies as was analysis of the reasons not following the protocol and its association to outcome.

Comparing our study to these studies, a similar effect on reduction of complications, hospital LOS, readmissions, gastroparesis, time to enteral feeding and time to mobilization was found. Our present study also illustrates that it is feasible to implement a CP that covers the entire clinical admission, applying different targets of the various involved units (e.g. focus on hemodynamic and respiratory vital parameters at the PACU/ICU, versus focus on EWS and ERAS criteria at the
Lessons Learned

This study shows us, in line with the implementation of our cardiac surgery CP and oesophageal surgery CP, that it is feasible to develop and implement a CP for pancreaticoduodenectomy procedures for all involved units like the PACU/ICU and surgical ward through the entire clinical perioperative period. In all units, the CP targets need to be aligned and the use of a variance report discriminates complication-related to failure of professional adherence. Implementation is an iterative process that takes time to become comfortable in use for all involved units. Key nurses together with medical leadership were essential for awareness, feedback and motivation during development, implementation and the use of the CP.

Future Perspectives

In order to overcome the methodological drawbacks of this study and to validate the CP methods, a multicenter stepped-wedged cluster randomized controlled trial would be ideal. However, due to the complexity of the implementation and intervention with barrier and facilitator analysis in different hospitals and units, interpretation of the results will be difficult. Exploring the validity of similar CPs is in line with the need for quality assurance of standardized treatment regimes with high protocol adherences.

For the near future, continuous monitoring, wearables and electronic medical data recording with pop-up facilities warning medical and nursing staff for deviations from the CP will likely be of help in building more complex pathways. Possibly, patients with high comorbidity will be able to follow their personalized clinical pathway (pCP) with the help of dedicated staff.

Conclusion

The use of the CP was associated with a reduction of perioperative morbidity. Essential new tools include a variance report analysis, scheduled barrier and facilitator analyses and the iterative PAR cycle protocol development, performed by a multidisciplinary team. Development, implementation and use of a CP throughout the hospital stay for patients undergoing pancreaticoduodenectomy are a multistep procedure in which we showed that this is feasible and safe.

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Conflict of Interest

The authors declare that they have no conflict of interest.

Compliance with Ethical Standards

Conflict of Interest

The authors declare that they have no conflict of interest.
Table 4  Similarities and differences between clinical pathway and control period

| Location          | Clinical pathway                                                                 | Control                                                                 |
|-------------------|----------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| **Outpatient clinic** | Tumour board treatment advice (PACON)                                             | Tumour board treatment advice (PACON)                                   |
|                   | Oral and written patient information                                              | Oral patient information                                                |
|                   | Dietician contact: MUST screening tool, nutrition advice and if needed             | Dietician contact if needed supplemental feeding oral or enteral        |
|                   | supplemental feeding oral or enteral                                              |                                                                         |
|                   | Frailty screening tool                                                            |                                                                         |
|                   | Medication verification                                                           |                                                                         |
|                   | Training advice: home trainer use, 1-h walking per day                            |                                                                         |
| **Surgical ward**  | Use of ERAS protocol                                                              | Use of ERAS protocol                                                    |
|                   | Preoperative lanreotide®                                                          | Preoperative lanreotide®                                                |
|                   | Thrombosis prophylaxis nadroparine® 5700 E                                       | Thrombosis prophylaxis nadroparine® 2850 E                              |
|                   | 6:00 day of operation: last preop or clear liquid intake, anti-thrombosis          |                                                                         |
|                   | compression stockings.                                                            |                                                                         |
|                   | Pain management and control according to protocol together with pain service team | Pain management together with pain service team                         |
|                   | Early warning score once per 8 h and whenever indicated together with actions by  | Early warning score once per 8 h and whenever indicated action by resident |
|                   | nurses                                                                            |                                                                         |
|                   | Patient communication between doctors, nurses and handover situations according   | Patient communication between doctors, nurses and handover situations not specified |
|                   | to Reason, Story, Vital Signs and Plan (RSVP)                                     |                                                                         |
|                   | Mobilization after surgery: swing and out of bed within 24 h                     | Mobilization after surgery: swing and out of bed within 24 h            |
|                   | Gastric tube: if production <200 ml in 12 h, remove tube                          | Gastric tube: if production is reduced, start clamp tube and remove if retention is <100 ml in 8 h (after two consecutive periods of 8 h) |
|                   | Drain removal if production <200 ml and amylase <500 U/l per day                  | Drain removal if amylase <500 U/l per day and operating surgeon agrees  |
|                   | Nutrition: MUST >2, start TPN on day 1 post-operative                             | Nutrition: enteral feeding will start on day 1 if the patient has a     |
|                   | MUST = 1: if gastric tube has not been removed on day 3, start TPN                | jejunalostomy. Oral fluids according to ERAS                           |
|                   | All patients: if the gastric tube cannot be removed because of                    | If no enteral intake is possible on day 6, TPN has to start on day    |
|                   | gastroparesis on day 7 without signs of sepsis or ileus: placement of a           | 7                                                                      |
|                   | jejunal tube through the gastrojejunostomy by the gastroenterologist and         |                                                                         |
|                   | start enteral feeding                                                             |                                                                         |
|                   | Glucose control                                                                  | Glucose control                                                         |
|                   | Discharge criteria                                                                | Discharge criteria not specified                                        |
|                   | Use of the variance report if actions are not according to protocol.              |                                                                         |
| **Operating room** | Use of ERAS protocol                                                              | Use of ERAS protocol                                                    |
|                   | Pain control by epidural catheter                                                 | Pain control by epidural catheter                                       |
|                   | Central venous line in the vena jugularis, if indicated PiCCO                     | Antibiotic prophylaxis 15–60-min pre-incision. Cefazoline® and          |
|                   |                                                                                  | metronidazole®. If a stent or percutaneous transhepatic drain has been  |
|                   |                                                                                  | placed in the ductus choledochus, use piperacillin/tazobactam® as       |
|                   |                                                                                  | prophylaxis.                                                            |
|                   | Target post-operative fluid balance between 0 and 500 ml                          | Post-operative fluid balance not specified but according to ERAS         |
|                   | Handover to PACU team members by surgeon and anaesthesiologist according to Rsvp  | Handover to PACU team members by anaesthesiologist                      |
| **PACU/ICU**       | Entrance in PACU: every 15 min: RR and heart rate control until stable,           | Entrance in PACU: every 15 min: RR and pulse control until stable         |
|                   | than every 30 min RR and pulse                                                    | than every 30 min RR and pulse                                          |
|                   | Continuation of antibiotics will be part of the sign-out procedure after surgery  | Continuation of antibiotics at the decision of the surgeon              |
|                   | Normothermia (>36.0 °C), Bair Hugger or heating system if necessary               | Normothermia (>36.0 °C), Bair Hugger or heating system if necessary     |
|                   | Every hour (1st until 24th hour):                                                 | Every hour (1st until 24th hour):                                      |
|                   | Respiratory status after extubation: saturation, respiratory frequency,           | Respiratory status after extubation: saturation, respiratory frequency,   |
|                   | coughing and deep breathing exercises                                             | coughing and deep breathing exercises                                   |
| Clinical pathway | Control |
|------------------|---------|
| Hemodynamics: heart rhythm, heart frequency, RR, ScvO₂ (if indicated). | Hemodynamics: heart rhythm, heart frequency, RR, ScvO₂ (if indicated). |
| Excretions: urine, drain, gastric tube | Excretions: urine, drain, gastric tube |
| Temperature | Temperature |
| Pain and sedation: NRS pain score | Pain and sedation: NRS pain score |
| RASS and CAM ICU | RASS |
| Mean arterial pressure (MAP) between 70 and 100 mmHg and heart frequency between 60 and 90 per minute. Different targets than the CP prescribe possible after approval of the supervising anaesthesiologist. | Mean arterial pressure (MAP) targets need approval of the supervising anaesthesiologist. |
| MAP should be above 70 mmHg: if below, start norepinephrine. | |
| iv fluids: ERAS protocol | |
| Balance between 0 and +500 ml/24 h | |
| Urine production has to be above 0.5 ml/kg/h. Protocol ‘oliguria PACU’ | Urine production has to be above 0.5 ml/kg/h. Protocol ‘oliguria PACU’ |
| First choice of inotropics: dobutamine® | First choice of inotropics: supervising anaesthesiologist |
| Stress ulcer prophylaxis pantoprazole® 1 dd 40 mg iv/po | Stress ulcer prophylaxis pantoprazole® 1 dd 40 mg iv/po |
| Nausea and vomiting: 3/day 4 mg ondansetron® iv (maximum until 36 h after surgery) 3/day metoclopramide® 3/day 10 mg iv (3/day 5 mg iv when kidney function reduced) (cave QT time) | Nausea and vomiting: If indicated: 3/day 4 mg ondansetron® iv 3/day metoclopramide® 3 day 10 mg iv (3/day 5 mg iv when kidney function reduced) (cave QT time) |
| Anti-thrombosis prophylaxis nadroparine® 5700IE | Anti-thrombosis prophylaxis nadroparine® 2850 IE |
| Mobilization according to protocol: starts within 24 h | |
| Gastric tube: see CP surgical ward | Gastric tube |
| Drain: 2 abdominal drains | Drain: 2 abdominal drains |
| Drain production control every hour: aspect and volume, 100–200 ml/h. If production >200 ml/h or >400 ml/4 h, contact surgeon | Drain production control every hour: aspect and volume, 100–200 ml/h. If production >200 ml/h or >400 ml/4 h, contact surgeon |
| Electrolyte control and interventions | Electrolyte control and interventions |
| Glucose regulation: normoglycaemia (glucose 5.0–10.0 mmol/l) | Glucose regulation: normoglycaemia (glucose 5.0–10.0 mmol/l) |
| Discharge criteria: handover procedure according to RSVP, vital signs accepted by the surgical ward. | Discharge criteria according to PACU |
| Use of the variance report if actions are not according to protocol. | |
### Appendix 2

**Sticker patient**

| CP Pancreatecolectomy/WHipple, total pancreatectomy and if indicated for other pancreatectomy patients |
|---|---|---|---|---|
| **D E N** | **N** | **G** | **N** | **I** |
| **Restriction** | **Varianse observed** | **Intervention** |
| Start oral intake (enteral feeds/liquid diet) | Start fluids and if possible 60 ml/day small meals |
| Start enteral route (EN) (oral fluids) | Start fluids and if possible 60 ml/day small meals |
| **D E N** | **N** | **G** | **N** | **I** |
| Mouthwash | Multiscorer | NST 2 |
| No mouthwash | NST 2 |
| **D E N** | **N** | **G** | **N** | **I** |
| **Woundcare** | **Varianse observed** | **Intervention** |
| Incision site care protocol | No gastric tube |
| No incision site care protocol | Stop oral intake |

**D E N Signs**

| **Input/Output** | **Varianse observed** | **Intervention** |
|---|---|---|
| Blood loss | Blood loss > 100 ml/h | Stop blood transfusions |
| **Gastrointestinal** | **Varianse observed** | **Intervention** |
| Nausea/vomiting | Nausea/vomiting > 3x | Stop oral intake |
| Diarrhea | Vomitting 2x in 12 h | Stop oral intake |
| Diarrhea | Diarrhea > 100 ml/h | Stop oral intake |
| **D E N Other** | **Varianse observed** | **Intervention** |
| **Blood pressure** | Blood pressure < 90/60 mmHg | Start fluids and if possible 60 ml/day small meals |

**D E N**

| **Input/Output** | **Varianse observed** | **Intervention** |
|---|---|---|
| Fluid intake | Fluid intake > 2 L/day | Start fluids and if possible 60 ml/day small meals |
| **Gastrointestinal** | **Varianse observed** | **Intervention** |
| Nausea/vomiting | Nausea/vomiting > 3 | Stop oral intake |
| Diarrhea | Diarrhea > 100 ml/h | Stop oral intake |
| **D E N** | **Varianse observed** | **Intervention** |
| **Blood pressure** | Blood pressure < 90/60 mmHg | Start fluids and if possible 60 ml/day small meals |

**D E N**

| **Input/Output** | **Varianse observed** | **Intervention** |
|---|---|---|
| Fluid intake | Fluid intake > 2 L/day | Start fluids and if possible 60 ml/day small meals |
| **Gastrointestinal** | **Varianse observed** | **Intervention** |
| Nausea/vomiting | Nausea/vomiting > 3 | Stop oral intake |
| Diarrhea | Diarrhea > 100 ml/h | Stop oral intake |
| **D E N** | **Varianse observed** | **Intervention** |
| **Blood pressure** | Blood pressure < 90/60 mmHg | Start fluids and if possible 60 ml/day small meals |

**D E N**

| **Input/Output** | **Varianse observed** | **Intervention** |
|---|---|---|
| Fluid intake | Fluid intake > 2 L/day | Start fluids and if possible 60 ml/day small meals |
| **Gastrointestinal** | **Varianse observed** | **Intervention** |
| Nausea/vomiting | Nausea/vomiting > 3 | Stop oral intake |
| Diarrhea | Diarrhea > 100 ml/h | Stop oral intake |
| **D E N** | **Varianse observed** | **Intervention** |
| **Blood pressure** | Blood pressure < 90/60 mmHg | Start fluids and if possible 60 ml/day small meals |
### Appendix 3

#### Variance CP
**POSTOPERATIVE (day 0/1-2)**
Pancreatioduodenectomy

| Variance respiratory status | Action | Medical Plan, time, action |
|----------------------------|--------|---------------------------|
| Patient is not extubated < 6 hours because extubation goals are not achieved. | ☐ contact doctor | ☐ |

#### Variance respiratory status after extubation

| SpO2 < 96% (in some patients a lower SpO2 is accepted, this should be part of the written treatment plan) | Action | Medical Plan, time, action |
|---------------------------------------------------------------------------------------------------|--------|---------------------------|
| ☐ discuss possible reasons with the patient | ☐ exclude pain and stress | ☐ O2 use maxi Strl |
| ☐ control oxygen supply/device | ☐ O2 use maxi Strl | ☐ control leakage |
| ☐ rest anesthetics? | ☐ | ☐ rest anesthetics? |
| ☐ stimulate efficient coughing (small pillow) | ☐ | ☐ |

If the result is not enough:

- ☐ check SpO2 at arrival in the hospital
- ☐ contact doctor
- ☐ start non-rebreathing mask or aquapack 100% after contact with doctor

| SpO2 at arrival in the hospital | ☐ non-rebreathing mask/aquapack 100% |
|--------------------------------|-------------------------------------|
| > .................................% | ☐ re-intubation |

| breathing frequency > 30 / minute | Action | Medical Plan, time, action |
|-----------------------------------|--------|---------------------------|
| ☐ SpO2 < 96%: see variance| ☐ SpO2 ≥ 96%: | ☐ unknown ? contact doctor |
| | ○ discuss possible reasons with the patient | ☐ exclude pain and stress |
| | ○ | ☐ |

breathing frequency < 10 / minute

| breathing frequency < 10 / minute | Action | Medical Plan, time, action |
|-----------------------------------|--------|---------------------------|
| ☐ observe and stimulate the patient | ☐ reason? Medication? | ☐ SpO2 < 96%: see variance SpO2 < 96% |
| ☐ contact doctor | ☐ contact doctor | ☐ contact doctor if apnoe and/or breathing frequency < 6 / minute |

#### Variance hemodynamic stability

| Variance hemodynamic stability | Action | Medical Plan, time, action |
|--------------------------------|--------|---------------------------|
| all combinations of hemodynamic changes including sinusrhythm > 90 / minute | ☐ control situation physiology on arrival in the hospital | ☐ contact doctor |

| New rhythm and/ or disrhythmia | Action | Medical Plan, time, action |
|-------------------------------|--------|---------------------------|
| ☐ uptaint ECG | ☐ contact doctor | Rhythm analysis: |

| ABP MAP < 70 mm Hg | Action | Medical Plan, time, action |
|-------------------|--------|---------------------------|
| ☐ contact doctor | ☐ | |

| ABP MAP > 100 mm Hg or systolic bloodpressure >150 mm Hg | Action | Medical Plan, time, action |
|--------------------------------------------------------|--------|---------------------------|
| ☐ contact doctor | ☐ | |

| ABP MAP 70 - 100 mm Hg if PICCO | Action | Medical Plan, time, action |
|--------------------------------|--------|---------------------------|
| - CI > 3.0 l/min/m2 | ☐ If results are not sufficient after 2x 250 ml : contact doctor | ☐ 1st Volulyte® 250 ml ..........................time |
| - ITBVi < 850 ml/m2 | 2nd Volulyte® 250 ml ..........................time | ☐ result not sufficient: |
| - EVLWi < 10 of > 10 ml/kg | ☐ contact doctor | ☐ |

| ABP MAP 70 - 100 mm Hg if PICCO | Action | Medical Plan, time, action |
|--------------------------------|--------|---------------------------|
| - CI > 3.0 l/min/m2 | ☐ contact doctor | ☐ |
| - ITBVi > 850 ml/m2 | ☐ | |
| - EVLWi > 10 ml/kg | ☐ | |
| Variance | Action | Medical Plan, time, action |
|----------|--------|---------------------------|
| **Variance Excretion** | | |
| Diuresis < 0.5 ml/kg/hour | □ control function of bladder catheter<br>□ contact doctor | □ |
| Abdominal drain leakage | □ contact doctor if signs of infection<br>□ contact doctor if bandage has to be renewed 2x per shift because of fluid loss | □ |

| Variance Temperature | Action | Medical Plan, time, action |
|----------------------|--------|---------------------------|
| < 35,0 °C | □ start Bair Hugger®/heating system<br>□ breathing air has to be warm if the patient is still on the ventilator | □ |
| < 36,0 °C | □ start Bair Hugger®/heating system | □ |
| > 38,0 °C | □ contact doctor | □ postoperative inflammatory response of infection related |

| Variance Pain en Sedation | Action | Medical Plan, time, action |
|---------------------------|--------|---------------------------|
| Sedated patient | □ continue sedation if temperature < 36,0 °C<br>□ reduce sedation depending on blood results or stop sedation if temp > 36,0 °C and the patient is hemodynamic and respiratory stable and no anesthesia (TOF) | □ Start of Sedation reduction …………………hour<br>□ Sedation stop …………………hour |
| NRS > 4 because of wound pain and the patient is on pain medication | □ control epidural block<br>60 minutes after start of extra pain medication (in contact with doctor):<br>□ New measure of NRS/CPOST<br>□ communicate with doctor for extra pain medication<br>□ contact doctor about the need of diagnostics and consultation | □ |

| Variance general | Action | Medical Plan, time, action |
|------------------|--------|---------------------------|
| Patient lies in a position of 45° | □ control<br>□ if not than put in right position 45 degrees | □ |
| Subcutaneous emphysema | □ contact doctor | □ |
| Patient has nausea | □ Ondansetron 4 mg i.v.<br>□ insufficient result contact doctor | □ |
| Patient has fear and stress | □ communicate fear and stress with the patient<br>□ insufficient result contact doctor | □ |
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