A Structured Program for Teaching Pancreatojejunostomy Outside the Operating Room

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Abstract

Background: Pancreateojunostomy (PJ) is one of the most difficult and challenging abdominal surgical procedures. Most trainees learn this procedure in the operating room (OR) because there are no appropriate training systems available outside the OR. This extends the learning curve and may affect patient safety. We developed a structured program for teaching PJ to increase training opportunities outside the OR.

Methods: We have created this structured program to help trainees acquire both didactic knowledge and technical skills to perform PJ. A manual was created to provide general knowledge about PJ and the specific PJ procedure used in our institution. Based on questionnaires completed by trainers and trainees, the procedure for PJ was divided into twelve steps and described in detail. After creating the manual, we developed organ models, needles and a frame box for simulation training.

Results: Trainees learn about PJ by reading the procedure manual, acquiring both general and specific knowledge. We conducted simulation training outside the OR using the training materials created for this system. Training was performed with participants referring to the procedure manual while performing the simulation training. They simulate the procedure with surgical instruments as both primary and assistant surgeon. After finishing the anastomosis, trainees inspect the resulting structures from all angles including the posterior side and intraluminally, which cannot be observed during the actual operation.

Conclusion: We developed a structured program for teaching PJ. By implementing this program, it is expected that a trainee's learning curve will be shortened while ensuring patient safety.

Background

A surgical procedure consists of multiple tasks. To complete the tasks effectively and safely, a surgeon must have both appropriate didactic knowledge and technical skills. Therefore, acquiring knowledge regarding procedures and training in technical skills are both essential. Challenging surgical procedures require surgeons to perform challenging tasks. Pancreateojunostomy (PJ) is considered one of the most difficult and challenging abdominal surgery procedures. Difficulties with this procedure can lead to serious complications and poor outcomes. [1] [2] Pancreatic surgeons must acquire both advanced knowledge and refined technical skills to perform PJ.

However, there are several problems associated with teaching the PJ procedure. First, there is no single standardized technique for this procedure. There are many variants of the PJ. There are differences in the way the procedure is performed among surgeons, even in the same institution. [3] Second, training opportunities are very limited. Patient safety must be considered when teaching this procedure. An effective training program is needed for the PJ procedure. To date, there are no standard programs for teaching PJ outside the operating room (OR) with appropriate teaching materials.
The aim of this study is to develop a structured program to teach PJ outside the OR. In developing this structured program, we created a procedure manual and physical simulation models as teaching materials to create a complete system for teaching PJ.

**Methods**

To establish a structured program for trainees to learn the technique for PJ, we created a procedure manual and teaching materials including organ models, needles and a frame-box for simulation training of PJ. The target trainees are surgeons certified by the Japan Surgical Society at post-graduate year 6 or above and have never performed a PJ anastomosis with our modified Blumgart technique. Many of these trainees are seeking advanced training in hepatobiliary surgery (similar to a fellowship in many countries).

1) **Creation of the procedure manual and standardization of the PJ technique**

We created a procedure manual including general and specific knowledge about the PJ. General knowledge in the manual includes preoperative risk assessment, a review of techniques used to perform a PJ and a discussion of postoperative complications. The manual specifically describes the modified Blumgart technique, which is the standard technique adopted at our institution for PJ in patients with soft pancreatic parenchyma and a non-dilated main pancreatic duct.

We have a number of senior surgeons who serve as instructors, but we want to teach a single way to perform this procedure to our trainees. The wide range of variations in technique used make it difficult for instructors to teach one method for the procedure as baseline-level knowledge. To minimize technical differences among the instructors, we utilized a repeated questionnaire. First, a trainee, who had never performed the PJ, made a list of questions to instructors about PJ after going through materials including surgery videos, operative reports and references. The questions were collated and then given to a panel of six board-certified surgeons, all accredited by the Japanese society of hepato-biliary-pancreatic surgery. Responses were kept anonymous. The results of the first survey were compiled. Points of agreement and disagreement among instructors were identified. An additional questionnaire based on the results of first survey was then created and a second survey carried out. We repeated these anonymous surveys to obtain a basic consensus among our experts regarding technical differences. This allowed development of a procedure manual with a unified approach. In the procedure manual, we divided the PJ procedure into twelve steps and state the purposes of each step clearly. (Table 1) The standardized procedure is described in as much detail as possible. Simple illustrations are also used to increase the level of understanding of the procedure. (Fig. 1)
2) Creation of teaching materials for simulating the surgical procedure

Based on the manual that we created for the standard PJ technique, we developed teaching materials necessary for physical simulation training. We developed high-fidelity organ models including a pancreas model and a small bowel model. The organ models were developed to meet the following two requirements. First, they must replicate the anatomical features required to perform simulation training. Second, the models can be utilized for simulation training with regular surgical instruments, sutures and needles. The pancreas model replicates a pancreas with soft parenchyma and a non-dilated main pancreatic duct. The main pancreatic duct has a diameter of 1.5 mm and is located slightly dorsal and cranial to the center. The small bowel model has a diameter of approximately 2 cm and is 40 cm long. The models were made from polyvinyl chloride (PVC) which has elasticity. The models were especially designed to contain fibers to reduce the incidence of splitting after suturing. One model set can be utilized for four anastomosis training sessions. We developed them in conjunction with FASOTEC Medical Engineering Company (Chiba, Japan). [4] (Fig. 2)

To reduce the costs of this training, we also developed needles for simulation training in conjunction with CROWNJUN Inc. (Tokyo, Japan). The needles are the same length, thickness, and curvature as the standard items utilized in our institution. Nylon was selected as the suture material to further reduce costs.

We believe that the working environment is an important component of a simulation teaching system. There are two important factors affecting the difficulty of the actual operation. The first factor is the size of the abdominal incision. The second is the depth from top of the abdominal wall to the remnant pancreas. Small incisions and deep surgical sites make the procedure more difficult. To simulate these two factors, we created a frame box. Elastic rings are used to reproduce the size of the abdominal incision. Different size rings are used to control the size of the opening. A large one is 22 cm and a small one is 18 cm in diameter. To reproduce the depth of the surgical site from the abdominal wall to the target organs, we control the height of both the ring and the model with the frame box and the fixed base. (Fig. 3)

Results

Teaching PJ outside the OR

Step 1) Self-learning of general and specific knowledge regarding PJ
Trainees start by learning about PJ by reading the procedure manual by themselves. The trainees can acquire both general knowledge and specific knowledge. Risk factors and early diagnosis and treatment of postoperative pancreatic fistula are especially important aspects of general knowledge. In the specific knowledge section, trainees learn the basic concepts and purposes of the standardized PJ technique in words. The standardized process was divided into twelve steps. There are clear purposes and tips discussed for each step. Trainees can acquire specific knowledge for each step with text, numbers and illustrations as preparation for simulation training.

**Step 2) Simulation training with physical models (Additional files 1,2,3)**

We conduct simulation training outside the OR using the training materials created for this system. Training was performed with participants referring to the procedure manual on a tablet screen while performing the simulation training. A trainee and a trainer worked together and took the roles of primary surgeon and assistant surgeon alternately. (Fig. 4)

Standard surgical instruments were used for the simulation training. The trainer asked the trainee if anything was unclear, and the trainer gave the trainee advice and feedback at each step of the procedure in a highly interactive manner. (Fig. 5) After finishing an anastomosis, the trainee could observe the view from posterior side and from inside the small bowel, which cannot be observed in the actual operation. This observation offered an important educational benefit of using realistically designed physical models in a simulation. (Fig. 6)

**Discussion**

To perform any surgical procedure safely, both didactic knowledge and technical skills are essential. Adequate knowledge is necessary to understand the indications for surgery, recognize the intraoperative situation, select the correct technique and provide appropriate postoperative management. Accurate technical skills are indispensable to complete any surgical procedure. Therefore, when creating a teaching program for a surgical procedure, it must include both didactic knowledge and technical skills. To effectively and safely perform a complex procedure such as PJ, a surgeon must acquire both advanced knowledge and advanced technical skills.

Didactic knowledge of surgical procedures can be generally divided into general knowledge and specific knowledge for each procedure. In general, standardization is effective for teaching and learning surgical procedures. However, there are many kinds of techniques to perform a PJ and there is no single technique that has emerged as the gold standard for PJ. Using a standardized technique and consistent practice of that single technique may lead to a decreased rate of complication, but defining that standard technique remains problematic. [5] [6]
In this study, we first created a detailed procedure manual for our own PJ technique because there were differences in the technique even among surgeons at the same institution. Basic agreement was obtained by a repeated anonymous questionnaire to obtain a consensus view of the best way to teach PJ. This approach was embraced by the faculty and assured them that everyone’s opinion would be considered in defining the best way to teach PJ, rather than everyone following the ideas of just one person. The purpose and tips for each step were verbalized, digitized and illustrated in order to improve the trainee’s understanding.

To acquire surgical skill, training both in the OR and outside the OR with simulation has become required in many training programs. Until recently, surgical skills were acquired through a traditional apprenticeship model of training. Almost all surgical training took place in the OR with trainees performing more or fewer components of a procedure with varied levels of supervision by faculty, and varied levels of awareness of these realities by the patients. Simulation training has been a part of surgical education over the past few decades. [7] Many reports show the usefulness of the simulation training in many aspects. [8] [9] [10]

There are various kinds of simulation training, such as cadaver training, animal laboratory training, virtual reality training and training with inanimate models. Each of these scenarios is associated with various advantages and disadvantages. Cadaver training has limited opportunities for trainees usually because of the lack of cadavers. In animal laboratory training, the anatomy may not be similar to humans and there may be ethical issues. In virtual reality training, development of the training software and user interfaces is expensive and still limited in scope. In training with manufactured models, the trainee can have numerous training opportunities and there are no ethical concerns. However, suitable models do not exist for training for many complex procedures. Development of meaningful training programs with inanimate models requires a great deal of input by clinicians and educators.

With the recent development of three-dimensional modeling technology, it has become possible to create models to use for training in complex procedures. [11] [12] [13] We used this technology to develop training models for PJ. These models reproduce human anatomy with great accuracy to facilitate PJ training. These teaching models made it possible to teach suturing and ligation on anatomically accurate models, which can be used multiple times. A simple frame box was added to the simulation to adjust the difficulty of training. The difficulty of PJ is influenced by access through the abdominal incision and depth of the surgical field. Especially, the depth of the operative field is a risk factor of the postoperative pancreatic fistula. [14] The influence of both of these factors on training for PJ can be adjusted with this teaching system.

Simulation training with this program facilitates team training. Trainees can alternate roles as both primary surgeon and assistant which increases the overall understanding of the procedure. This also helps trainees and trainers develop non-technical skills which are necessary for surgeons. [15] [16]

There are two major issues which remain to be solved. The first issue is the cost of the program. The dry lab training model set including the pancreas and the small intestine costs about US$100 to produce. It is
possible to use one set for four PJ anastomoses. The needles cost about US$70 for a single anastomosis. Therefore, it costs about US$380 (set of models plus needles) to perform four anastomoses during a training session. Further cost reductions may be possible with mass production and devising new materials. The second issue to be solved is how to evaluate the effectiveness of this program. There are many studies about usefulness of the simulation training in minimally invasive surgery, however evaluation in open surgery is still inadequate. [17] [18] [19] Since it is difficult to assess patient outcomes from an ethical point of view, both objective and subjective assessments are needed. We are currently devising an evaluation to improve the program and increase competency of the trainees.

Conclusion

We have developed a simulation program for teaching PJ. By implementing this program, it is expected that a trainee's learning curve will be shortened while ensuring patient safety.

Abbreviations

PJ: pancreatojejunostomy

OR: operating room

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and material

Not applicable

Competing interests

The all author declare that they have no competing interests.

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**Author’s contributions**

All authors read and approved the final manuscript. Kenichi Oshiro and Kazuhiro Endo are equally contributed to this study.

Study concept: KO, KE

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Drafting of the manuscript: KO, KE, AL

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