


Can the transection plane be optimized in pancreatic resections?

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Received: July 4, 2022 • Revised manuscript received: November 2, 2022 • Accepted: November 29, 2022

Published online: February 8, 2023

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ABSTRACT

Purpose: According to current protocol, the separation of pancreatic head and body is performed at the level of superior mesenteric vein (SMV). Previous data indicate that the resection plane should be modified in portal annular pancreas. We presumed that the optimal line of pancreatic resections could also be different in other cases. Our aim is to simulate pancreatic resections in different planes and find the optimal resection line with the minimum number of cut vessels. **Main methods:** 25 abdominal vascular corrosion casts were prepared, the aorta and the portal vein were cannulated. CT scans were taken on the casts, and specific planes were reconstructed simulating different resection lines. The total amount of cross sections of vessels were calculated in the different planes. **Results:** In our series, the optimal plane is the SMV in 11/25, 2 cm left in 10/25, 1 cm left in 4/25, 1 cm right in 1/25 and 2 cm right in none of our cases. The group of left sided extension contain more than half of the cases. With left sided resections, the cut surface of the vessels may be lowered to even 29% compared to the SMV plane. **Conclusion:** Our study revealed that pancreatic resections should be extended to the left side of the SMV in more than half of our cases. Therefore, the resection plane should be determined by preoperative imaging methods. Using DICOM viewer with multiplanar reconstruction, the resection planes can be simulated in clinical practice, which would reduce the risk of postoperative bleeding.

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KEYWORDS

pancreas, pancreaticoduodenectomy, postoperative complications, multidetector computed tomography, corrosion casting

INTRODUCTION

The surgical treatment for pancreatic head tumors is the Whipple's procedure (pancreaticoduodenectomy, PD) and the modified pylorus preserving PD (PPPD). Both methods include the separation of the pancreatic head from the body. According to the current surgical protocol, the resection plane lies at the level of the superior mesenteric vein (SMV), however, in the variation of portal annular pancreas (PAP), it is already suggested to extend the resection to the left [1] to reduce the rate of postoperative bleeding. The shape of the pancreas—apart from the PAP—displays more frequent variations [2]. We presumed that the optimal line of pancreatic resections could be different from the level of the SMV in cases apart from the PAP.

The aim of this study is to simulate pancreatic resections in the plane of the SMV, and parallel planes in 1 and 2 cm distance from the SMV on both sides. Further object is to measure the transected vessel diameters in the chosen planes (Fig. 1). The total diameter of transected vessels correlate with the risk of intraoperative blood loss and postoperative bleeding, therefore it should be kept to a possible (potential) minimum.

The transection plane is defined optimal, when the total cut vessel surface is the lowest, therefore the incidence of postoperative bleeding would decrease.

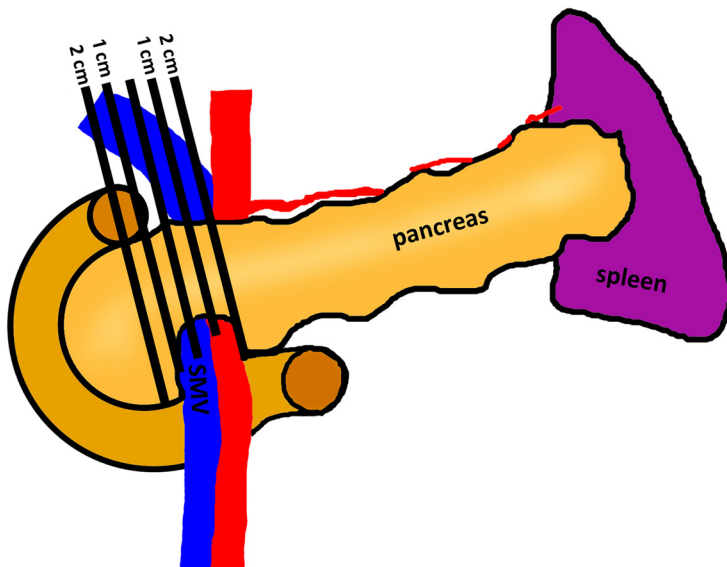


Fig. 1. The position of the simulated resection planes



MATERIALS AND METHODS

Vascular corrosion casts were prepared from a total of 25 abdominal organ complexes obtained from fresh human cadavers delivered to our department. Written permission had been obtained beforehand from the Local Ethical Committee. The donors had provided written consent for the use of their bodies for education and research purposes, prior to death. The investigation conforms to the principles outlined in the Declaration of Helsinki regarding the use of human tissues for research purposes. We have carefully checked the bodies outer abdominal region and the organ complex. Specimen with macroscopic alteration (any sign of pancreatic morphological change or abdominal trauma or surgical intervention in the upper abdominal region) were excluded from the study. We didn't have the opportunity to collect detailed premortal data on the cadavers. Therefore, data on sex, age and BMI and their relations to the vascular morphology of the pancreatic vasculature were not in focus of our study.

The proximal end of the abdominal aorta and the portal vein were cannulated, lumbar branches, renal arteries and the aorta above the origin of the inferior mesenteric artery were ligated.

Then a resin mixture developed by M. Kiss was prepared for injection. The viscosity of the resin was set to enter the vessels with a diameter of 1 mm. The amount of the injected red resin into the aorta was considered enough when it appeared in the subserosal arteries of the large intestine, the portal vein was filled with an amount of 50–80 ml yellow resin. KOH was added for the corrosion procedure [3].

The hardened vascular casts keep the original shape of the abdominal organs. CT scans were taken of the casts, using a Philips Brilliance 16 unit (parameters: 140 kV, 300 mAs, collimation: 16×0.75 mm, overlap 50%). Specific planes were reconstructed at the axis of the SMV, in 1 and 2 cm distance from the SMV on both sides using eRAD PACS software. An example is shown on Fig. 2, where the CT image shows the chosen planes on the corrosion casts. As the parenchyma is already removed by the corrosion procedure, the position of vessels (arteries and veins) with a greater caliber makes the orientation possible, the outline of the pancreas can be recognized by its dense vasculature (marked with red dots). The pixels on the territory of the pancreas were counted by ImageJ, and the cross section of the vessels were calculated, as the pixel size was known from the eRAD software. The examination was done by a qualified radiologist with more than five years of clinical experience. This method provides objective data on the pancreatic vasculature at the plane of resection, from which postoperative bleeding may occur.

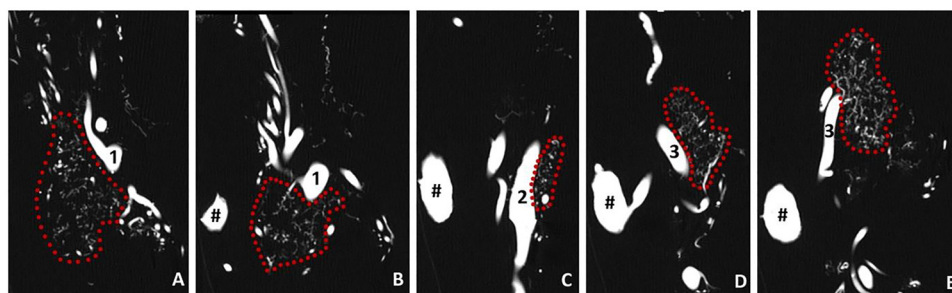


Fig. 2. Reconstructed planes. A: 2 cm right; B: 1 cm right; C: level of SMV; D: 1 cm left; E: 2 cm left. 1: portal vein; 2: SMV; 3: splenic vein; #: abdominal aorta; the outline of the pancreas is marked with red dots



RESULTS

The measurements resulted in data of a wide range depending on the size of the pancreas, therefore the data were standardized to the plane of the SMV. In Table 1, the total vascular resection surface found in specific planes were related as percentages of total sectional profiles of the plane of SMV. From the collected data, the line of resection is selected by the lowest value of vascular resection surface.

The surgical resection is advisable in the plane with the achievable lowest number of vascular injuries. In our series of 25 specimens, the advised plane is the SMV in 11 cases, 2 cm to the left of SMV in 10 cases, 1 cm to the left of SMV in 4 cases, 1 cm to the right of SMV in 1 case and 2 cm to the right of SMV in none of our cases (Fig. 3). In sample No. 20. the SMV plane and the plane 1 cm to the left from it both displayed the same value of vascular resection surface.

The highest number of cases showing the lowest values are found in the SMV plane group (11 of 25), but the left sided extensions (1 or 2 cm to the left of SMV) contains more than half of

Table 1. Total vascular diameters in different transection planes related to the standard SMV plane in percentages. Lowest values are italicized, presenting the optimal resection surface in each sample

Sample No.	2 cm right % of the standard plane	1 cm right % of the standard plane	SMV standard resection plane	1 cm left % of the standard plane	2 cm left % of the standard plane
1.	199%	169%	100%	37%	61%
2.	182%	275%	100%	127%	96%
3.	91%	189%	100%	72%	68%
4.	216%	262%	100%	148%	130%
5.	87%	61%	100%	198%	119%
6.	71%	197%	100%	53%	49%
7.	168%	124%	100%	52%	49%
8.	293%	230%	100%	48%	58%
9.	96%	137%	100%	34%	29%
10.	379%	122%	100%	107%	200%
11.	126%	126%	100%	94%	112%
12.	180%	202%	100%	141%	111%
13.	283%	493%	100%	253%	130%
14.	279%	337%	100%	135%	165%
15.	159%	322%	100%	240%	243%
16.	177%	154%	100%	123%	40%
17.	265%	360%	100%	124%	87%
18.	335%	621%	100%	165%	192%
19.	41%	95%	100%	44%	29%
20.	144%	175%	100%	100%	115%
21.	214%	248%	100%	102%	74%
22.	815%	995%	100%	305%	300%
23.	207%	179%	100%	120%	123%
24.	463%	248%	100%	278%	893%
25.	238%	299%	100%	82%	74%



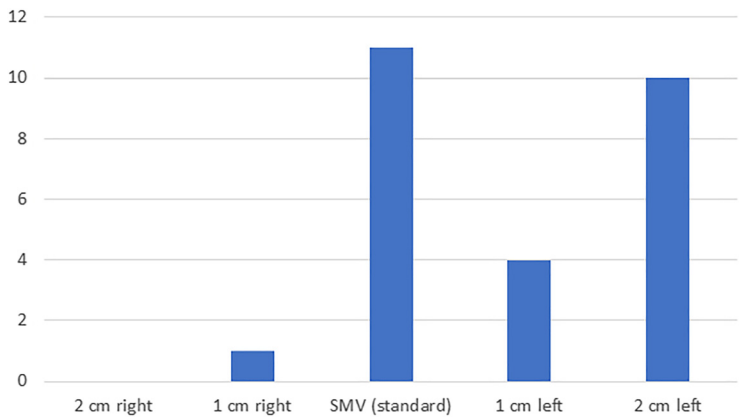


Fig. 3. The location of the optimal resection plane in our series of 25 specimen

our cases (14 of 25). With left sided resections, the surface of transected vessels may be lowered to even 29% compared to the SMV plane.

DISCUSSION

Our results correlate with recent surgical research on pancreatic resection. Matsui et al. [4] found less bleeding in cases of modified left resection lines, and Partelli et al. [5] stated that the amount of blood loss is correlated with the thickness of the cut parenchyma, both authors conducted studies in distal pancreatectomies.

Postoperative bleeding and postoperative pancreatic fistula (POPF) are the most common complications after pancreatic resections. Riediger et al. [6] found that the incidence of POPF correlates with the morphology of the pancreatic resection plane (their study provided data based on the pancreatic parenchyma diameter and pancreatic duct width ratio). As our study provided data on the cut vessel surface, concerning to the literature, it may have relationship with the size of the resection plane, therefore the incidence of POPF may be also lowered with an optimal resection line.

The strength of our study is that it presented precise and detailed data on the cut vessel surfaces in different planes. The CT simulation of different resection planes was accomplished on anatomical corrosion cast specimens, but the method is reproducible in clinical use. An evaluated preoperative CT angiography with multiplanar reconstruction could reduce postoperative bleeding.

Our study also had limitations. First, a higher number of corrosion casts series is needed for a detailed statistical analysis, but even on a series of 25 specimens, we found more than half of our cases (14 of 25), where a modified resection plane would be optimal to lower the morbidity of postoperative bleeding. Second, our study focuses on the vasculature only. Measurement of the pancreatic ducts diameters and the pancreatic parenchyma would show detailed data about the risks of POPF in theoretical resection planes. As Akamatsu found, a thick parenchyma and a tiny duct are risk factors of POPF [7]. Our further plan is to make improved specimen proving also data on the pancreatic duct system. Finally, according to Kang, mild increase of



parenchymal loss may enhance the incidence of postoperative glucose intolerance in case of an extended pancreatic resection. Other risk factors of postoperative glucose intolerance are also published, for example higher BMI or female gender [8].

In conclusion, the outcome of our anatomical study supplemented with CT measurements and simulations showed that in more than half of our cases, pancreatic resections could be optimized by choosing a transection plane on the left side of the SMV, exhibiting lower values of cut vessel surface. This may indicate lower risk of postoperative bleeding. Therefore, it is recommended that the resection plane should be determined by the preoperative imaging methods, since abdominal CT or MR is almost always done on patients, who undergo pancreatic resection. Using DICOM viewer software with multiplanar reconstruction option, the resection planes can be simulated in clinical practice.

Conflict of interest: The authors declare no conflict of interest.

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