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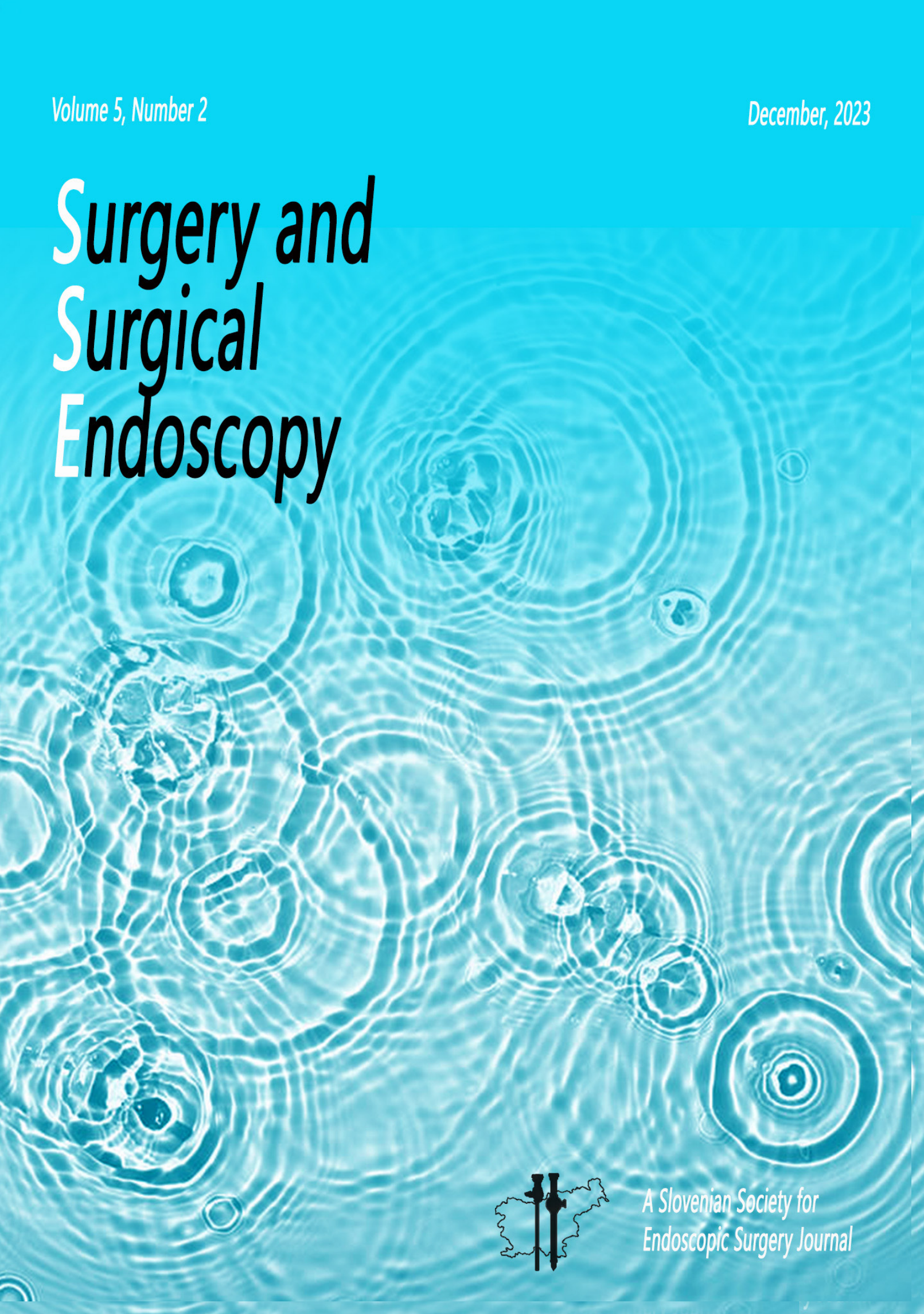

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Impressum

ABOUT THE JOURNAL

Surgery and Surgical Endoscopy is a fully open-access, peer-reviewed journal that aspires to publish articles relevant to surgery, surgical oncology, and surgical endoscopy from researchers worldwide. The journal accepts research articles, review-articles, case reports, letters to the editors, study protocols, and "How I do it" submissions. We also publish submissions that accompany educational videos, which are published on our official YouTube site.

SSE is the official Journal of the Slovenian Society of Endoscopic Surgery.

A signed authorship declaration form must accompany all manuscripts. Instructions for authors, instructions for submitting videos, the authorship declaration form, and the description of the peer review process can be found below.

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Surgery and Surgical Endoscopy

December 2023

Editorial

Assist. Prof. Tomaz Jagric, MD, Ph.D., and Assist. Prof. Jan Grosek, MD, Ph.D., Editors of Surgery and Surgical Endoscopy

Dear fellow colegues,

With the festival season approaching, we are excited to present a special treat for you. We are pleased to announce the release of the second volume of the official journal of the Society for Endoscopic Surgeons of Slovenia. The final issue of 2023 features a diverse range of contributions covering topics such as cardiovascular, plastic, and general surgery.

The first of two cardiovascular contributions deals with the critical issue of choosing the correct aortic valve size. This is a fascinating topic since no consensus on the best or the most reproducible method has been reached. The same goes for the second cardiovascular article, which summarizes the current status of short-term mechanical cardiac support and highlights the future directions of this continuously evolving field of mechanical-assisted support.

In this issue, we also present a concise overview of the current therapeutical options for diabetic foot ulcers. This is a commonplace problem of surgical evaluation, but unfortunately, surgeons often do not put enough thought into the best treatment options for these patients.

Our December issue features three case reports. The first is a rare condition of antral gastric diverticulitis that presented as an early-onset gastric outlet obstruction. The patient had 16 years of complaints and many inconclusive tests before she was finally operated on with minimally invasive surgery.

The second case report is a presentation of a right-sided diaphragmatic hernia incidentally discovered during laparoscopic cholecystectomy due to symptomatic cholecystolithiasis. The authors describe their treatment approach for the patient's specific case and summarize current recommendations, as no guidelines are available for these patients.

The third case report, with a review of the literature, is an incredibly captivating case of a traumatic pancreatic injury. Pancreatic injuries are quite challenging to diagnose early on and even more difficult to treat. The authors make a beautiful case presentation alongside a precise overview of the current treatment guidelines in this issue.

Finally, we present a »How do I do it« paper on the first laparoscopic transhiatal extended proximal gastrectomy and distal esophagectomy with articulated instruments in Slovenia. This benchmark paper will most definitely bring many benefits to patients with esophagogastric junctional carcinoma.

As you can see, we have concluded 2023 with an issue with diverse, intriguing, and exciting topics. Hopefully, this will be the hallmark of an even more successful year in 2024.

Dear colleagues, please enjoy the issue, and I hope you have a blessed and prosperous year 2024.

Surgery and Surgical Endoscopy

December 2023

Original article

Aortic annulus sizing: echocardiographic and computed tomography versus direct surgical sizing

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Keywords: aortic annulus, computed tomography, transesophageal echocardiography, sizing

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Abstract

Background: Correct preoperative aortic annulus sizing for transcatheter or surgical aortic valve replacement procedures is needed to choose the most appropriate valve for each patient. Computed tomography and transesophageal echocardiography are preoperatively used to determine aortic valve annulus sizing. Our study aimed to evaluate the correlation of aortic annulus size as measured by either transesophageal echocardiography or computed tomography with direct intraoperative surgical measurements.

Materials and Methods: The study included 41 patients in whom intraoperative aortic valve diameters were directly measured during surgical aortic valve replacement procedures; those values were compared with the diameters measured preoperatively by transesophageal echocardiography or computed tomography scanning.

Results: Computed tomography and echocardiographic diameters determined by transesophageal echocardiography showed a high correlation ($r = 0.633$ [95% CI 0.404 – 0.787], $P < 0.001$ and $r = 0.735$ [95% CI 0.552 – 0.850], $P < 0.001$, respectively) with intraoperative sizing. The Bland Altman Graph showed a good agreement between intraoperative sizing and transesophageal echocardiography and computed tomography measurements.

Conclusions: Our study demonstrated excellent agreement of transesophageal echocardiography and computed tomography measurements to intraoperative sizing. The data confirm that

although computed tomography may give more information about the calcification and shape, transesophageal echocardiography can very tightly predict the size of the aortic valve annulus.
Significance: transesophageal echocardiography can very tightly predict the size of the aortic valve annulus and computed tomography provides more information about calcification and shape.

INTRODUCTION

Preoperative assessment of the aortic valve annulus is crucial for safe and accurate aortic valve replacement or implants in various procedures. Direct intraoperative sizing is the gold standard for annular aortic measurements in surgical aortic valve replacement; the annulus can be sized directly, and the choice of valve size is based on the intraoperative measurement [1]. Unlike surgical aortic valve replacement, transcatheter aortic valve replacement requires a noninvasive assessment of the aortic annulus dimension to determine the size of the prosthesis to be implanted [2]. The lack of intraoperative direct sizing during transcatheter aortic valve replacement procedures makes preoperative imaging of the aortic annulus size indispensable [3].

An incorrect determination of the aortic annulus might lead to severe intraoperative complications, such as significant paravalvular leaks, annulus rupture, or valve embolization [4]. Aortic annulus measurements for transcatheter aortic valve replacement procedures routinely use transesophageal echocardiography, and measurements are performed at end-systole to measure the largest possible diameter [5, 6]. However, transesophageal echocardiography's two-dimensional view presents limitations. The annulus is not circular in all patients; it can be oval-shaped in various configurations [7], which may lead to an underestimation of the true aortic annulus diameter when a two-dimensional view is used. Computed tomography is another standard preoperative imaging modality. Our study aimed to evaluate the valve sizing performed by preoperative sizing with transesophageal echocardiography or computed tomography and compare the image measurement estimations to direct intraoperative measurements.

MATERIALS AND METHODS

This prospective study was approved by the local institutional review board (HSC-MS-14-0889) and conducted under a waiver of informed consent. Patients were enrolled if preoperative measurements from computed tomography and transesophageal echocardiography examinations were performed as part of the standard of care before a surgical aortic valve replacement procedure. During surgery, the direct intraoperative aortic valve diameters were measured by the surgeon and recorded by the study coordinator. Surgical procedures included aortic valve replacement alone or in combination with other cardiac procedures.

Experienced echocardiographers performed all transesophageal echocardiography procedures. The aortic annular diameter was measured in mid-esophageal long-axis view in end-diastole and end-systole. The distance between the hinge points of the aortic valve leaflets was measured in a two-dimensional, zoomed-up view per standard protocol [8].

Computed tomography scans were retrieved from the electronic medical record. The images were post-processed and analyzed by an independent research nurse on the same workstation. The minimum and maximum diameters were measured. The mean of these two measurements

was calculated. To calculate the effective diameter, the luminal circumference was measured, and the software displayed the area of this circumference.

Surgical aortic valve replacement was performed in a standardized fashion. After opening the aorta, aortic leaflets were excised. The decalcified aortic annulus was sized by using the standard valve sizes. The definite size was based on a sizer tightly passing through the annulus. Each sizer was then measured (in millimeters) to avoid variations in manufacturers' sizer diameters.

STATISTICAL ANALYSIS

Continuous variables were expressed as the mean ± standard deviation or median and inter-quartile range, according to normal or non-normal distribution. Categorical variables were expressed as a number and percentages. Pearson correlation coefficients were calculated with a two-tailed significance test to assess the correlation between operative aortic diameter measurement and measurements performed by computed tomography and transesophageal echocardiography, respectively. Bland–Altman plot was used to depict the mean value of transesophageal echocardiography and computed tomography measurements and their differences. A value of $P < 0.05$ was considered significant. We used StataCorp. (2021, Stata Statistical Software: Release 17. College Station, TX: StataCorp LLC) to perform all statistical analyses.

RESULTS

A total of 41 patients were enrolled in this study. The median age of patients was 63 years, and 73% were male (Table 1). Table 2 shows the results of the surgeon's direct intraoperative measurements of aortic diameter, the transesophageal echocardiography measurements, and the computed tomography calculations.

Table 1. Demographic and clinical characteristics of patients. Descriptive statistics are median (interquartile range) or number (frequency percentage).

Age (years)	**63 (56 – 68)**
Gender (male)	**30 (73%)**
Height (cm)	**172 (166 – 180)**
Weight (kg)	**85 (73 – 122)**
Race	
White	**26 (63%)**
Black	**4 (10%)**
Hispanic	**10 (24%)**
Asian	**1 (3%)**
NYHA class	
I	**2 (4%)**
II	**12 (30%)**
III	**17 (41%)**
IV	**10 (25%)**
Comorbidities	
Arterial hypertension	**27 (65%)**
Hyperlipidemia	**16 (39%)**
Diabetes mellitus	**17 (41%)**
Obesity (BMI > 30 mg/k^2)	**15 (37%)**
Coronary artery disease	**11 (27%)**
Atrial fibrillation	**5 (12%)**

Abbreviations: BMI, body mass index; NYHA, New York Heart Association

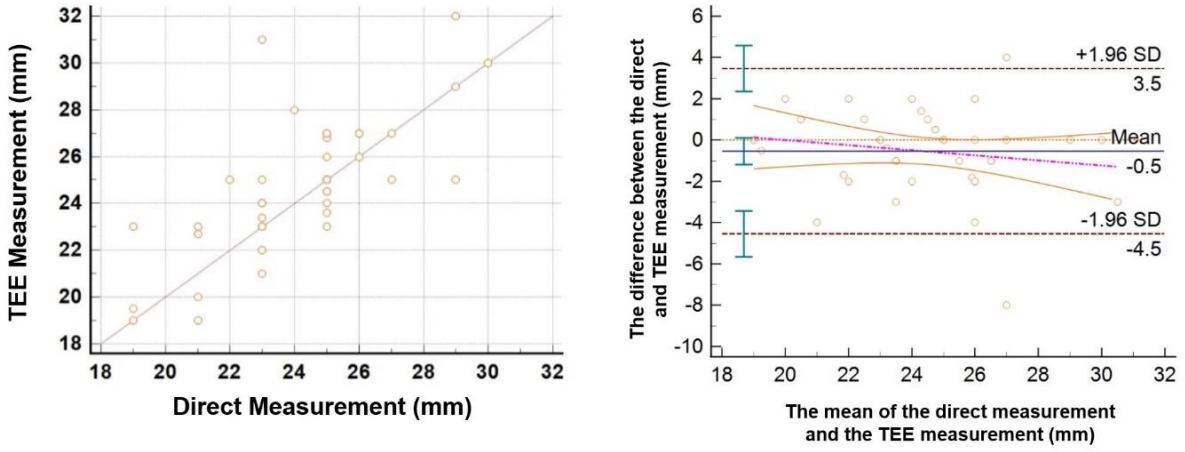
The data were analyzed for correlations between the direct intraoperative sizing and results of transesophageal echocardiography or computed tomography. Computed tomography and echocardiographic diameters determined by transesophageal echocardiography showed a high correlation ($r = 0.633$ [95% CI 0.404 – 0.787], $P < 0.001$ and $r = 0.735$ [95% CI 0.552 – 0.850], $P < 0.001$, respectively) with intraoperative sizing (Figures 1A, 2A, and 3A). These scattered diagrams show a high correlation between all methods,

Table 2. Different measurement modalities were used to obtain aortic diameter values.

	Actual sizing (mm)	TEE (mm)	CT (mm)
Aortic diameter (mean ± SD)	24.2 ± 2.6	24.7 ± 2.9	26.3 ± 3.6
Aortic diameter (median & IQR)	25 (23 – 25)	25 (23-27)	26 (23 – 28)

Abbreviations: CT, computed tomography; IQR, interquartile range; SD, standard deviation; TEE, transesophageal echocardiography

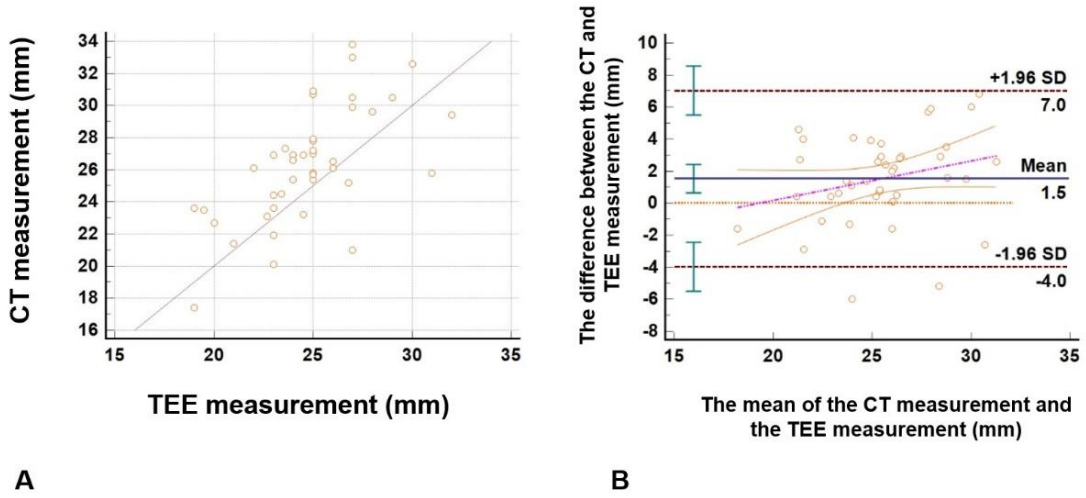
Figure 1.



A: Correlation between the measurement of the aortic annulus diameter with transesophageal echocardiography (TEE) and direct intraoperative measurement shows an excellent agreement between the measurements.

B: A graph showing the difference between TEE and direct intraoperative measurements against the mean of TEE and direct intraoperative measurements for the aortic annulus diameter. The limits of agreement are small enough to be confident that the TEE can be used in place of the direct measurement for clinical purposes.

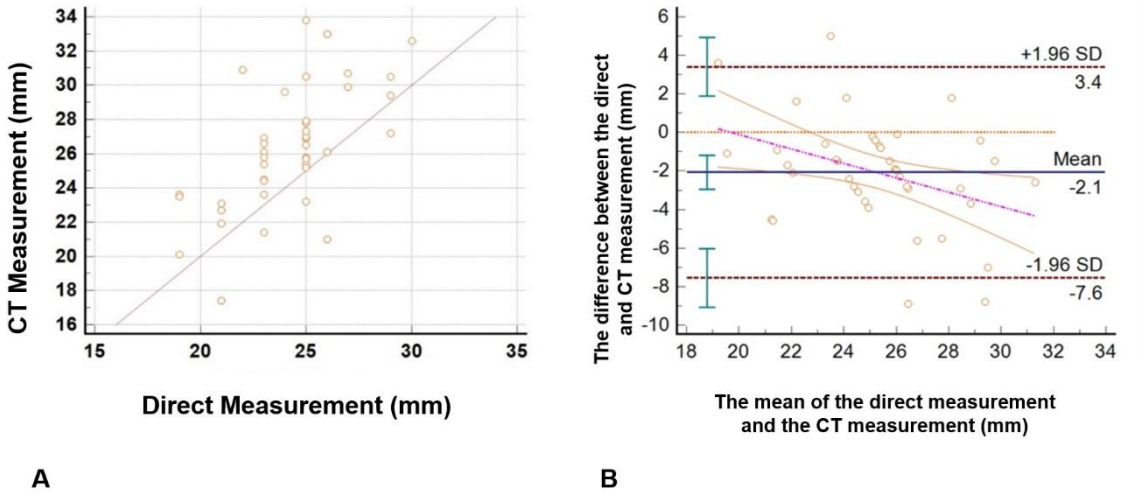
Figure 2.



A: Correlation between the measurement of the aortic annulus diameter with computed tomography (CT) and direct intraoperative measurement shows a good agreement between the measurements. However, the measurements with CT tend to overestimate the aortic diameter compared to direct measurements.

B: A graph showing the difference between CT and direct intraoperative measurements against the mean of CT and direct intraoperative measurements for the aortic annulus diameter. The limits of agreement are small enough to be confident that the CT can be used in place of the direct measurement for clinical purposes.

Figure 3.



A: Correlation between the measurement of the aortic annulus diameter with computed tomography (CT) and transesophageal echocardiography (TEE) shows a good agreement between the measurements. However, the measurements with CT tend to overestimate the aortic diameter compared to TEE.

B: A graph showing the difference between CT and TEE measurements against the mean of CT and TEE measurements for the aortic annulus diameter.

particularly between the direct intraoperative sizing and transesophageal echocardiography measurement of aortic annulus diameter.

For a more exact evaluation of the difference between the measurement techniques, Bland Altman's graphic presentation was used. The graphs showed a very low discrepancy and narrow limits of agreement between the compared measurements (Figures 1B, 2B, and 3B). The data is stored on a secure institutional server. De-identified data is available upon reasonable request.

DISCUSSION

In our study, end-systolic echocardiographic diameters determined by transesophageal echocardiography showed the best agreement with intraoperative sizing in the Bland-Altman analysis. Results of computed tomography and transesophageal echocardiography measurements were closely related to the direct size of intraoperative sizing of the aortic annulus. This indicates that recent technological advances in ultrasound imaging allow the presentation of real-time anatomical cardiac structure and function [9].

Teams routinely use a preoperative computed tomography scan to measure patients' aortic annulus and root anatomy scheduled for a transcatheter aortic valve replacement. In patients with an oval-shaped annulus, the effective diameter calculated from the circumferential area in the computed tomography scan showed a better agreement to intraoperative sizing and a stronger correlation than chocardiographic imaging [1]. Some studies also showed that computed tomography, in contrast to echocardiography, oversized the aortic annulus [3]. In our study, values of aortic diameter by computed tomography were not significantly larger than those determined intraoperatively.

While this study is limited by the small sample size and inherent bias of any retrospective imaging collection, the outcomes provide foundational data that can be used for future studies.

CONCLUSION

End-systolic transesophageal echocardiography images are very reliable preoperative aortic annulus sizing measurement techniques. Our study demonstrated excellent agreement to intraoperative sizing with narrow limits of agreement in the Bland-Altman analysis. The effective diameter calculated from the circumferential area in computed tomography scans may have an advantage compared to transesophageal echocardiography in patients with a pronounced oval-shaped annulus.

STATEMENTS AND DECLARATIONS

Ethics approval and consent to participate: This prospective study was approved by the local institutional review board (HSC-MS-14-0889) and conducted under a waiver of informed consent.

Consent for publication: Not applicable

Competing interests: The authors have no competing interests to declare.

Authors contributions: Design: PP, IDG, RR, BK; Data Analysis & Interpretation: PP, MJ, RR, AD, IDG; Drafting of Article: MJ, IDG; Critical Revision and Approval of Final Article: All Authors

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Surgery and Surgical Endoscopy

December 2023

Review article

Current status of short-term mechanical circulatory support

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Keywords: cardiogenic shock, acute heart failure, circulatory assist device, intra-aortic balloon pump, extracorporeal membrane oxygenation

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Abstract

Cardiogenic shock remains a major global burden regarding healthcare costs and patients' morbidity and mortality. Despite continual advances in pharmacological and invasive (percutaneous or surgical) therapy, it is currently well-accepted that short-term mechanical circulatory support represents the cornerstone in managing cardiogenic shock. Mechanical circulatory support has seen tremendous advances in the past two decades, especially in pump technology improvements, indication for use, surgical techniques for device implantation, and postoperative patient management. In the following review article, we review the latest advances in device technology and summarize the current status of short-term MCS indications and adverse effects.

INTRODUCTION

Cardiogenic shock represents a clinical entity with various aetiologies characterized by a sudden decrease in cardiac function and systemic hypoperfusion. Aetiologies vary from ischemic, valvular, and post-arrhythmic to post-cardiotomy or acute decompensations of chronic heart failure. Morbidity and mortality are extremely high in this patient population [1-4]. Diagnostic criteria include a systolic blood pressure (SBP) < 90 mm Hg or the requirement of vasopressor support to maintain an SBP of 90 mm Hg, cardiac index < 2.2 L/min/m2, pulmonary congestion, an elevated pulmonary capillary wedge pressure > 15 mm Hg, absence of hypovolemia, and signs of organ hypoperfusion (cool extremities, altered mental status, oliguria, and elevated serum lactate) [5]. Initial treatment

includes inotropic agents, vasodilators, diuretics, anticoagulants, volume management, and short-term mechanical circulatory support (MCS) [6]. All short-term MCS devices aim to alleviate shock and establish an environment where the native heart and end organs can recover. If recovery is unlikely, then a bridge to a long-term device may be the best strategy. With encouraging reports on mortality improvement, using short-term MCS with technological advancement and design improvement has increased rapidly in recent years [7]. This contemporary review summarizes the current status of short-term MCS and highlights the future directions of this continuously evolving field of mechanical-assisted support.

CURRENT STATUS: TEMPORARY DEVICES

Several short-term MCS devices are currently available for treating cardiogenic shock (Figure 1) [8].

The first line of mechanical assistance is the most modest: the intra-aortic balloon pump (IABP). The IABP was available in the 1960s, and the technology has not changed much. It reduces left ventricular

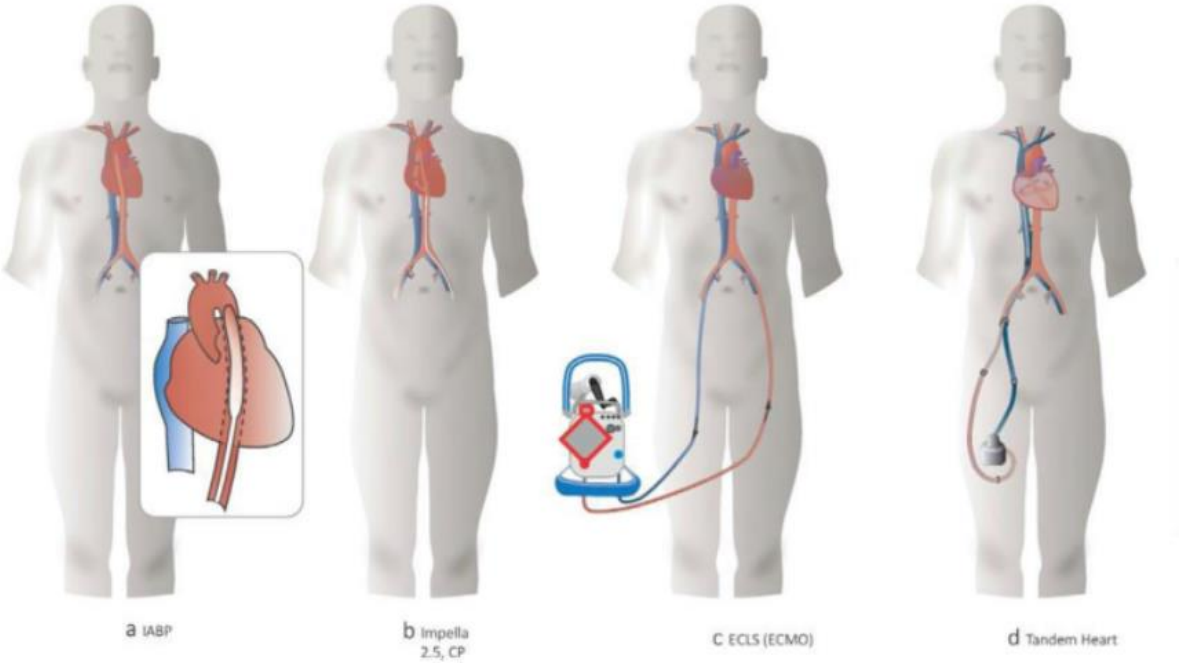

Figure 1. Overview of devices for acute mechanical circulatory support. ECLS, extracorporeal life support; ECMO, extracorporeal membrane oxygenation; IABP, intra-aortic balloon pump [8]

(LV) afterload in cardiac systole and increases coronary artery perfusion in cardiac diastole [9]. IABP support enhances myocardial contractility and improves LV ejection fraction. While an IABP is easily inserted via the femoral artery up to the origin of the left subclavian artery, some contraindications must be considered. Severe aortic valve regurgitation, peripheral arterial obstructive disease, and arrhythmias (balloon inflations/deflations are heart rate-dependent) are precluded using an IABP. The effects of the aortic counterpulsation were tested in the large, multicenter, randomized IABP-shock ii trial, which enrolled 600 patients with cardiogenic shock after acute myocardial infarction (AMI). Investigators could not show any improvement regarding short- or long-term mortality or adverse effects (10). This trial casts a shadow on the usefulness of the IABP in the intra- or postoperative period; it is seen as a tool best used before open heart surgery. Nevertheless, its simplicity, ease of bedside

insertion, staff familiarity, and low complication rate make IABP a popular choice in acute HF.

More advanced short-term MCS options include surgically-inserted devices, which can be broadly divided into continuous-flow or pulsatile-flow pumps. Two types of continuous-flow pumps are commercially available for extracorporeal circulation: roller pumps (rarely used in adults) and centrifugal pumps. According to a recent cross-sectional study on the use of short-term MCS in the USA, mostly continuous-flow centrifugal pumps have been used to support an acutely failing heart [7]. Extracorporeal membrane oxygenation (ECMO), tandemheart (tandemlife, livanova, london, uk), and impella (abiomed, danvers, ma, usa) are the most common support devices.

ECMO (or extracorporeal life support, ECLS) provides robust biventricular support in patients with severe refractory cardiogenic shock. Hill and colleagues initially described ECMO in the 1970s as a temporary oxygenation and pulmonary support technique, which has evolved dramatically since then [11, 12]. The use of ECMO in adults was infrequent until the publication of the cesar trial, which coincided with the h1n1 epidemic in 2009 [13]. Like the cardiopulmonary bypass machine used in day-to-day cardiac surgery, ECMO functions without using the reservoir. Consequently, stasis areas are absent, and lower doses of heparin could be used [14]. Cannulas can be inserted peripherally or centrally (in severe post-cardiotomy cardiogenic shock) [15]. Unlike IABP, ECMO increases lv afterload, which could further compromise the weakened lv. Thus, additional lv unloading means are desired (axial pump or venting through the right superior pulmonary vein). Contraindications to veno-arterial ECMO include severe peripheral artery disease (percutaneous only) and greater than moderate aortic regurgitation. The newest model is the cardiohelp (maquet cardiovascular, rastatt, germany), which has a reported survival of 60% [16].

Like ECMO, the tandemheart consists of drainage and return cannulas, a centrifugal pump, and a console regulating the pump; however, it does not have a membrane oxygenator. Initially designed for short-term support during high-risk percutaneous interventions in the catheterization laboratory, tandemheart has the unique feature of a trans-septal draining cannula, which offers excellent LV unloading. The issues of left-sided congestion, which sometimes plague ECMO patients, are non-existent. However, it provides lower support overall in comparison to ECMO. Successful reports using tandemheart span from post-ischemic ventricular septal defects to critical aortic stenosis and even mechanical support as bridge-to-transplant (17, 18). The presence of a left-sided thrombus is a counterindication. It should be noted that using a tandemheart beyond 6 hours and using an oxygenator are both off-label.

The impealla, a microaxial, continuous flow pump, is the most recent addition to the market. Like the tandemheart, the impella provides sufficient lv unloading, yet it is positioned differently. It is directed through the aortic valve into the left ventricle and commonly inserted peripherally through the axillary artery. Physiologically, it provides active forward flow, thereby increasing coronary flow and cardiac output [19]. The basis for the propagation of impella use was the protect ii trial, where impella provided superior hemodynamic support compared to IABP with similar incidences of adverse events [20]. The presence of a metallic aortic valve precludes the use of this device.

CURRENT STATUS: INDICATIONS

Despite the rising trend in short-term MCS implantation over the last two decades, the most appropriate timing for hemodynamic support in

cardiogenic shock patients remains unclear. Physicians must individually balance the risk of death and multiorgan system failure with the risk of surgery and related adverse effects from mechanical non-physiologic circulatory support. Patients with acute cardiogenic shock are classified as intermacs 1 ("the crashing and burning" patient profile) and are potentially too sick for durable ventricular assist device therapy [21]. The SCAI classification is an easily performed bedside assessment that stratifies patients with cardiogenic shock into five categories: stage a, the at-risk patient; stage b, the patient with beginning CS; stage c, the patient with classic CS; stage d, the deteriorating/doom patient; and stage e, the extremes patient [22]. The indications for acute MCS in cardiogenic shock patients vary due to the heterogeneity in both etiology and severity of presentation. In addition to the baseline characteristics of patients with cardiogenic shock, the indication may also go by the expected endpoints of the support (recovery, bridge-to-decision, mid- to long-term support). It is essential to consider exit strategies from acute MCS to minimize medically futile cases [8]. Historically and currently, inotropes and vasopressors are first-line therapies for hemodynamic instability and cardiogenic shock [6]. Early initiation of acute MCS can mitigate the consequences of systemic hypoperfusion, worsening ischemia, and declining cardiac function by relieving ischemic burden, augmenting cardiac output, and minimizing medications with high cardiac oxygen demands [23]. Unfortunately, most published data are from case reports and observational studies. Due to the nature of the disease and the heterogeneity of this patient population, the design and implementation of future randomized trials are challenging. To summarize indications, temporary circulatory support is recommended for patients with AMI-related complications, acute-on-chronic heart failure, and refractory arrhythmias as well as those undergoing high-risk percutaneous interventions (primary coronary interventions, complex ablations) and those slow to wean from CPB after heart surgery, [8, 24-26].

CURRENT STATUS: ADVERSE EFFECTS

With the growing population of patients supported by short-term MCS technology, clinicians involved in treating patients with cardiogenic shock face a myriad of adverse events that not only influence survival and quality of life but also have important effects on the costs. The most commonly encountered adverse effects are limb ischemia, bleeding, and hemolysis, with no significant difference between the above pumps. However, there are some product-specific complications. With the impella, injury to the aortic valve is not uncommon, and ventricular arrhythmias and LV perforations have been reported. Left ventricular dilatation in patients supported by ECMO is due to its failure to unload the LV successfully. Visceral ischemia could be encountered in all systems but is most frequently seen with the IABP. A significant left-to-right shunt could result from the trans-septal canula dislodgment with the tandemheart.

CONCLUSION

Currently, advances in short-term MCS technology are happening at a brisk pace. The trend is evident: to go smaller and more straightforward. Less aggressive surgical approaches, pump developments, and postoperative patient management improvements have made us look beyond pure survival outcomes in the cardiogenic shock population. The focus has shifted to the reduction of adverse events and readmissions.

STATEMENTS AND DECLARATIONS

Ethics approval and consent to participate:

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Surgery and Surgical Endoscopy

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"How do I do it" article

Totally laparoscopic transhiatal proximal gastrectomy and distal esophagectomy with articulated laparoscopic instruments

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Keywords: esophagogastric junction carcinoma, laparoscopic proximal gastrectomy, articulated instruments

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Abstract

Background: The paper presents the first case of laparoscopic transhiatal extended proximal gastrectomy with esophagogastric anastomosis with articulated instruments.
Case presentation: We present a case of a 67-years-old male patient with a tumor of the gastric cardia Siewert II, with 4 cm gastric extension. We performed a totally laparoscopic transhiatal extended distal esophagectomy and proximal gastrectomy with a esophagogastric mediastinal anastomosis.
Conclusion: In the present case, we confirmed that the reconstruction with the articulated instrument is feasible and offers decisive advantages to conventional laparoscopic instruments during the reconstructive phase.

INTRODUCTION

There is not much debate on the surgical treatment of tumors of the distal esophagus (Siewert I) and proximal third gastric cancers (Siewert III) [1, 2]. Patients with adenocarcinoma of the distal esophagus were treated with Ivor-Lweis or McKeown distal esophagectomy with right thoracotomy and proximal gastrectomy. On the other hand, patients with tumors located in the proximal third of the stomach were treated with total gastrectomy and transhiatal distal esophagectomy. Meanwhile, there is still no consensus on the best approach for patients with tumors of the anatomical cardia (Siewert II). Some authors advise a transabdominal approach, while others favor a thoracoabdominal approach [3]. The latter procedures carry a high early and late morbidity. A recent meta-analysis has shown that postoperative pneumonia in the transthoracic group was significantly higher than in the transabdominal group [3].

Adding to this, it has been shown that the incidence of upper and middle mediastinal lymph node metastases is infrequent [5, 6]. Based on these findings, the Japanese Gastric Cancer Society has advocated that patients with upper gastric cancer and esophagogastric cancer with up to 2 cm invasion of the esophagus upper and middle mediastinal lymphadenectomy is not necessary, and a transabdominal approach is better [4]. The patients have been shown to have equivalent long-term survival with less perioperative morbidity [6, 7, 8]. The open transabdominal approach, although less traumatic for the patient than the transthoracic approach, is still an extensive procedure. Minimally invasive surgery has offered a substantial decrease in surgical trauma. In addition, many studies have confirmed the advantage of minimally invasive surgery for esophagogastric tumors [9].

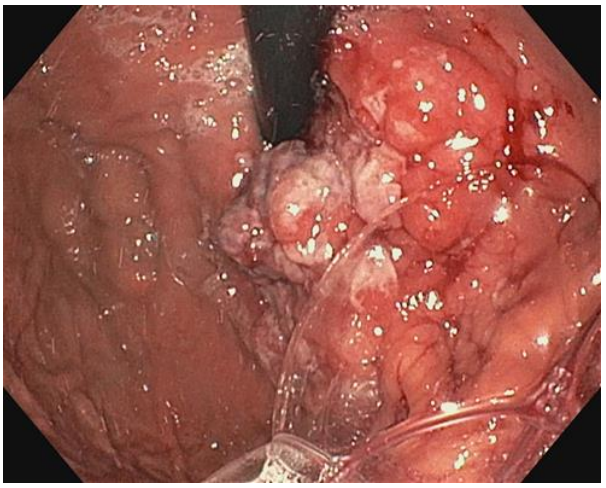
On the other hand, the confined space, difficult digestive tract reconstruction, high incidence of anastomotic leakage, and pulmonary infection make laparoscopic surgical treatment extremely challenging. An excellent option for his region are the robotic platforms. The dexterity of the surgical instruments in the transhiatal reconstruction bring forth a decisive advantage compared to laparoscopic surgery. At the same time, the rest of the procedure can be safe, faster, and cheaper with a conventional laparoscopic approach. To overcome the restraints of the laparoscopic instruments in the transhiatal reconstructive phase in the transhiatal extended proximal gastrectomy, we introduced articulated instruments for constructing the esophagogastric anastomosis. The paper presents the first case of laparoscopic transhiatal extended proximal gastrectomy with esophagogastric anastomosis with articulated instruments.

CASE PRESENTATION

We present a case of a 67-year-old male patient who has been suffering from dyspeptic complaints and weight loss for two months. He had a previous history of ischemic heart disease and suffered a heart attack. He had been treated with percutaneous coronary artery stenting. He had a hemodynamic unimportant stenosis of the right coronary artery. He had mild heart failure but was compensated in good general condition.

He has been admitted to a regional hospital for diagnostics. On upper gastrointestinal endoscopy, a tumor formation of the gastric cardia has been noted (Figure 1). The esophageal mucosa appeared normal, while the tumor invaded the cardia and spread 40 mm below the cardia towards the greater curvature of the stomach. The histology confirmed an adenocarcinoma of the cardia. He was classified as a gastric predominant tumor of the cardia, Siewert II.

Figure 1. Upper gastrointestinal endoscopy (scope in inversion).



On the upper gastrointestinal endoscopy in inversion of the scope a tumor is seen on the cardia and extending towards the lesser curvature.

Computer tomography of the thorax and abdomen excluded distal metastases and confirmed some enlarged paracardial lymph nodes.

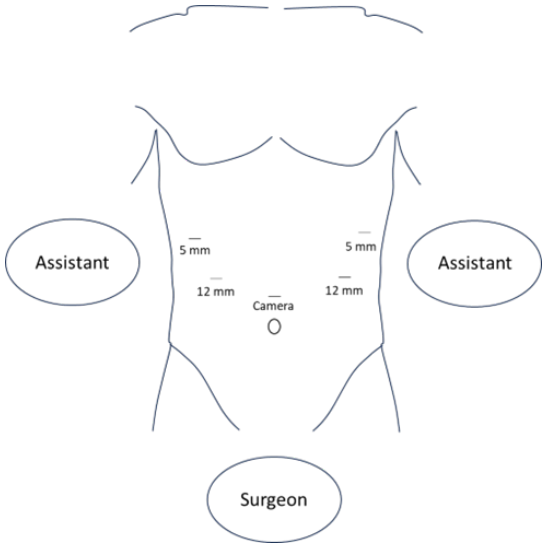
His case was presented on a tumor board. The patient was found unfit for perioperative

chemotherapy, and it was decided to proceed with surgery. After careful staging evaluation and the evaluation of endoscopic findings, we decided to perform a laparoscopic transhiatal extended proximal gastrectomy with distal esophagectomy.

SURGERY

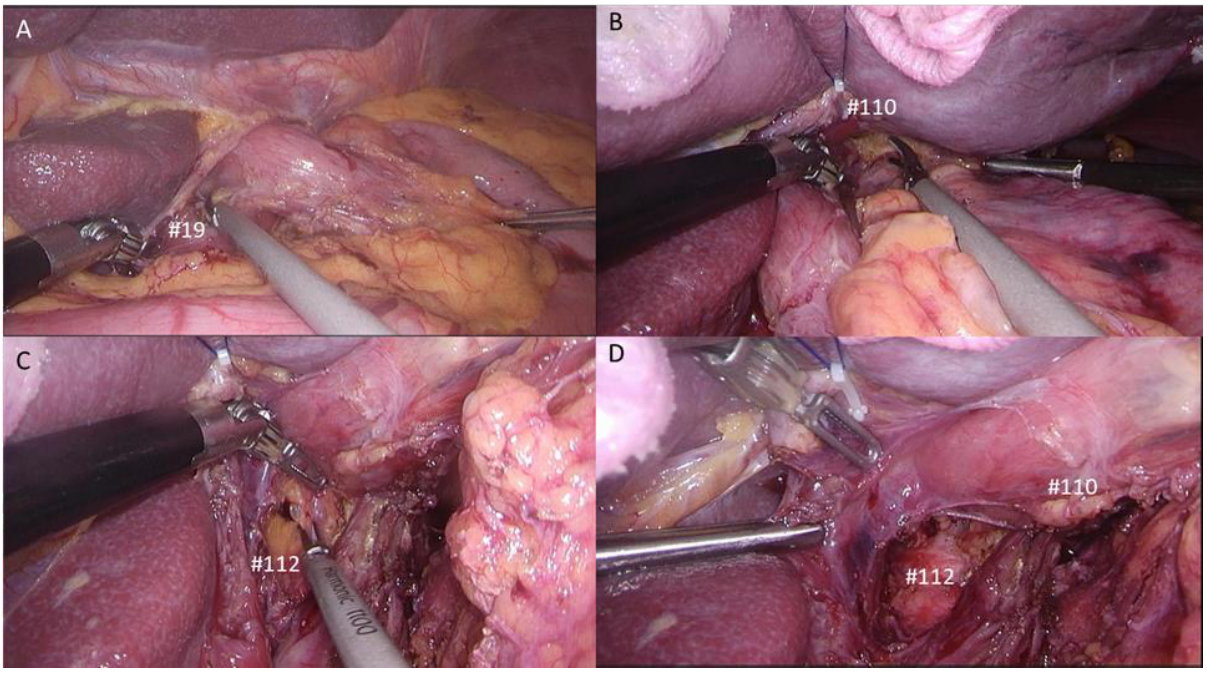
The patient was placed in a prone anti-trendelenburg position with legs abducted. The surgeon was positioned between the legs, while the first assistant stood on the right side during the initial phase of the operation and later on the left side during the reconstructive phase (Figure 2). A laparoscopic camera holder was used (Mofixx, Indes Service & Production, Netherlands).

Figure 2. The position of the surgical team and the trocar placement.



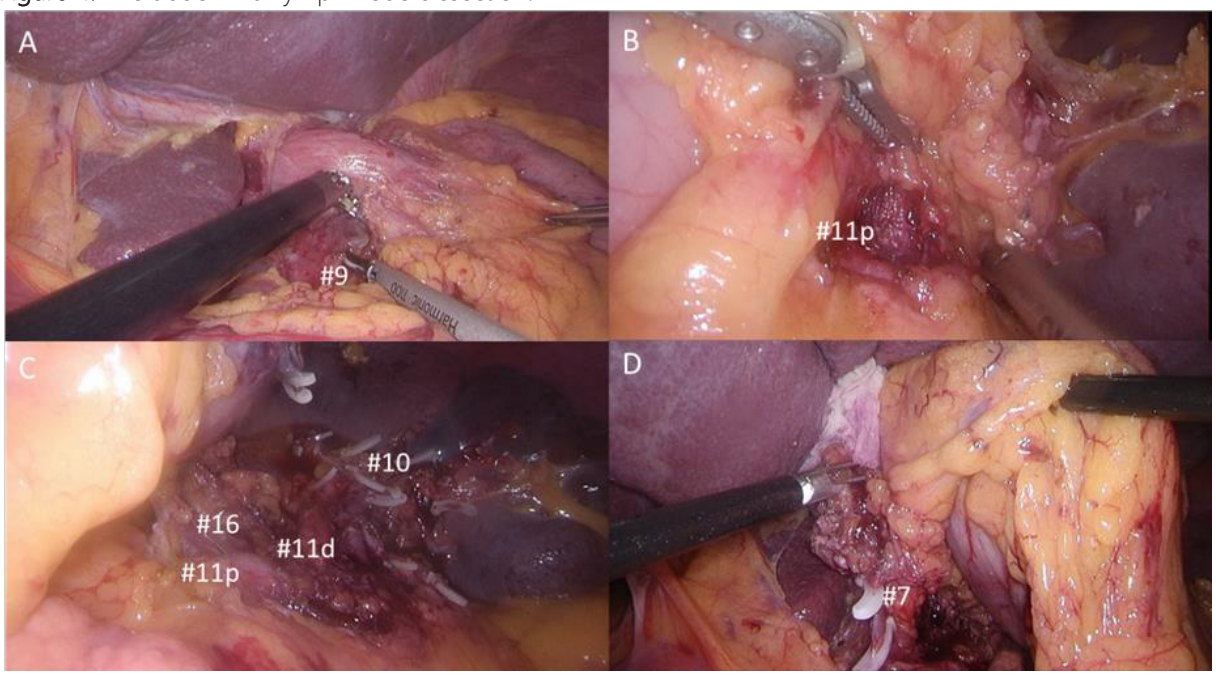
After establishing pneumoperitoneum, four additional ports were placed (Figure 2). The first step was the fixation of the falciform ligament and mobilization and fixation of the left liver lobe to expose the diaphragmatic hiatus. Then we transected the hepatogastric ligament and mobilized the esophagogastric junction by incision of the phreoesphageal ligament, exposing the right diaphragmatic pillar. The number 19 lymph node station was dissected at this stage, and the retro esophageal space was presented. At the same time, the coeliac lymph nodes were resented and dissected up to the level of the aorta. Then, the esophagus was taped for easier and atraumatic retraction. The next step was the dissection of the lower mediastinal lymph nodes. For this step, an articulated grasper was used (ArtiSential Livsmed EMEA, Germany). The mediastinum was entered from the right side, exposing the number 110 lymph nodes and finishing with the mobilization of the right side of the esophagus. The mobilization continued towards the left, exposing the left crus of the diaphragm, the left number 110 lymph nodes, and the lymph nodes number 20 (Figure 3). The dissection was continued towards the gastric fundus and upper portion of the spleen. We proceeded with the dissection of the greater curvature. After dissection of the take-off of the left gastroepiploic artery at its origin, we continued with the spleen-preserving splenic hilum dissection. The number 10 lymph nodes were at the end of the operation sent for a separate pathologic evaluation. After completing the greater curvature dissection, we completed the lymph node dissection of the 11 and 16 lymph nodes. The next step was the dissection of the number 8 lymph nodes and the dissection of the left gastric vein and artery at its origin (Figure 4). Finally, we marked the proximal and distal dissection border with a marker. The stomach was first dissected with a linear stapler (EndoGia, Medtronic, USA), and the conduit was prepared. A gastrotomy and an esophagotomy were made to insert the linear stapler. A linear stapled esophagogastric anastomosis was performed (EndoGia, Medtronic, USA). In the next phase, we used an articulated stitch holder for the suturing of the anterior wall of the esophagogastrostomy. After completion of the anastomosis, an air-leak test was performed. Two abdominal drains were placed, and the specimen was extracted (Figure 5).

Figure 3. The transhiatal dissection of the lower mediastinum.



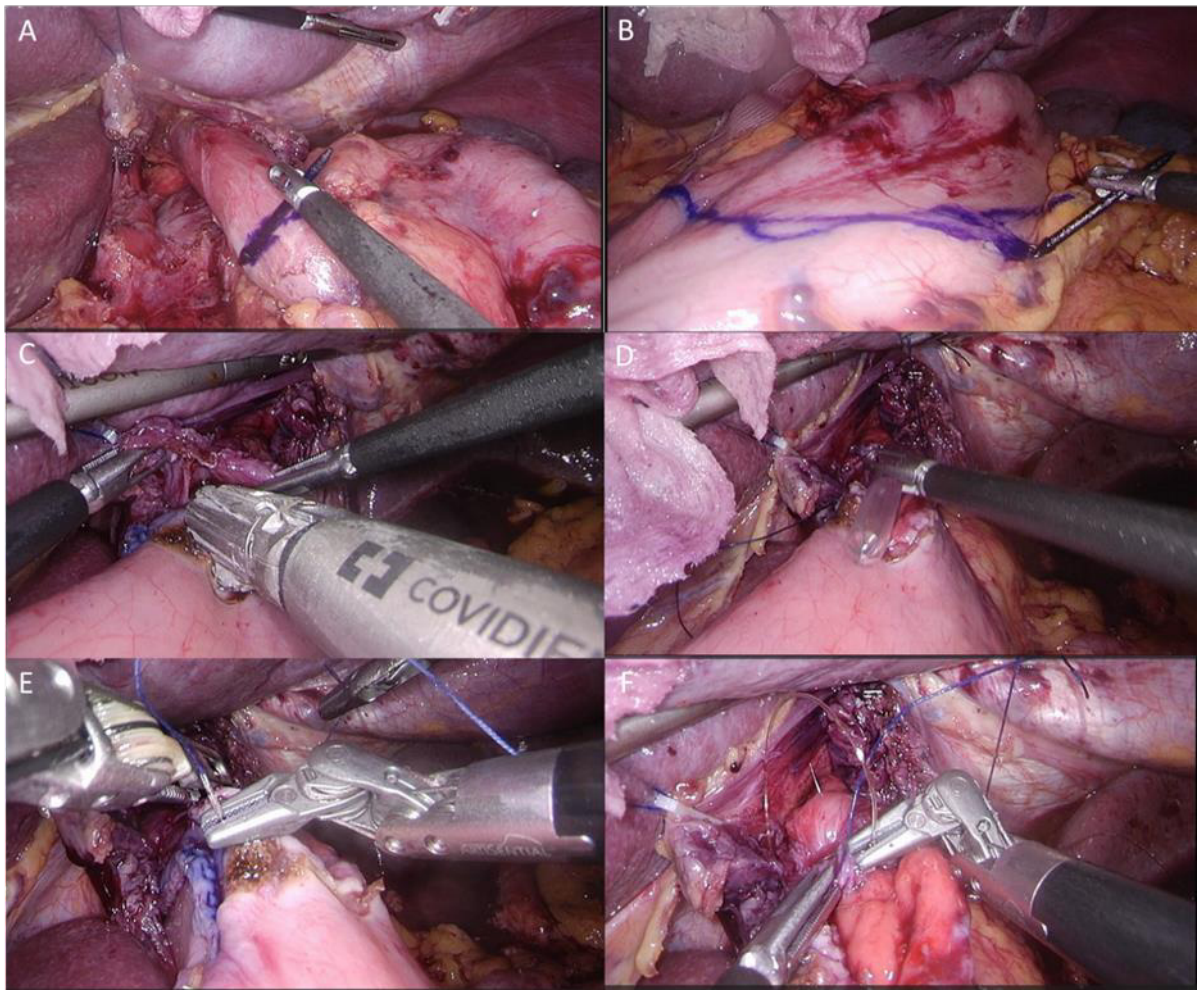
A: The entry into the mediastinum, dissection of the number 19 lymph nodes; B: Dissection of the number 110 lymph nodes and the mobilization of the right side of the esophagus. Dissection is carried out with an articulated instrument and an ultraconic scalpel; C: dissection of preaortal lymph nodes; D: final view; the preaortic lymph nodes have been dissected.

Figure 4. The abdominal lymph node dissection.



A: Dissection of the number 9 lymph nodes; B: Clearens of the lymph nodes along the splenic artery; C: complete clearence of the number 11, 10 and left number 16 lymph nodes; D: clipping and transection of left gastric artery.

Figure 5. Esophagogastric reconstruction.



A and B: marking of the proximal and distal transection borders; C: linear stapled anastomosis; D: passing of the nasogastric tube; E and F: suturing of the anterior wall with an articulated stitch holder.

The postoperative course was uneventful. The patient received clear fluids on the first postoperative day and solid diet on the 6th postoperative day. The abdominal drains were removed on the 5th postoperative day and the thoracic drain was removed on the 7th postoperative day. The patient was discharged on the 9th postoperative day.

The pathological exam revealed an intestinal type esophagogastric adenocarcinoma, with a pathological stage pT3N0(0/22)M0 with microscopic tumor free margins.

DISCUSSION

When considering surgical treatment for esophagogastric cancer patients, the extent of dissection and the anastomosis are two important factors to consider. Regarding the first point, Kurokawa et al. have shown that the incidence of upper and middle mediastinal lymph node metastases is rare in patients with up to 2 cm esophageal tumor invasion [4]. Hence, a less invasive procedure can be chosen for these patients. The transabdominal laparoscopic approach offers the least traumatic option but requires a challenging reconstruction. Laparoscopic instruments have a restricted range

of motion, which limits the possibilities when constructing an anastomosis. In this paper, we present a reconstruction technique using an articulated suture holder mimicking the robotic platform.

Park et al. were the first to describe the use of an articulated suturing instrument for the esophagogastric anastomosis [10]. They claimed that the articulation of the instruments has advantages comparable to robotic surgery in the reconstruction phase [10]. At the same time, the procedure's cost and duration are a fraction compared to robotic surgery. Park et al. described the reconstruction after proximal gastrectomy, with the construction of the anastomosis in the abdomen. In the present case, we presented the construction of a high anastomosis in the posterior mediastinum. The difficulty of construction of anastomosis in the mediastinum's confined space is unparalleled compared to abdominal anastomosis. The use of conventional laparoscopic instruments is very restricted in this narrow space. The diaphragmatic opening limits the angle between rigid instruments. This makes the placement of stitches difficult and often forces the surgeon to switch his working instruments between ports losing the view. The articulated instruments of a robotic platform are the best solution for this problem. However, it remains a question of how prudent it is to use the robotic platform only for the reconstruction step while the remaining procedure can be performed faster laparoscopically. The articulated laparoscopic instrument is an excellent hybrid solution to this problem. During the reconstruction phase, it allows access to all the angles of the esophagogastrostomy line through the midline position, while the assistants freely use the two lateral ports for presentation.

In the present case, we confirmed that the reconstruction with the articulated instrument is feasible and offers decisive advantages to conventional laparoscopic instruments during the reconstructive phase.

STATEMENTS AND DECLARATIONS

Conflicts of interest: There are no conflicts of interest.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patient(s) to publish this paper.

Ethics approval: The study was approved by the local ethics committee.

Conflicts of Interest: None declared.

Consent for publication: Not applicable.

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Case report

Case report of complete pancreatic neck transection trauma

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Keywords: isolated pancreatic injury, pancreatic trauma classification, distal pancreatectomy with splenectomy

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Article info

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Abstract

Pancreatic injury is a rare but critical condition with a high mortality rate due to complications including acute bleeding, sepsis, outflow of pancreatic juices into the abdominal cavity, pancreatitis, and the formation of abscesses and fistulas. The overall incidence of pancreatic injury in abdominal trauma is relatively low and is estimated between 0,2% and 12%. Blunt abdominal trauma can cause pancreas injury that ranges from mild contusion to complete transection with ductal disruption. The identification can be challenging due to nonspecific symptoms and low specificity of CT imaging for pancreatic duct injuries and can, therefore, cause delayed diagnosis. Delayed diagnosis drastically decreases the chances of good outcomes, especially in cases of ductal injury. It is essential to have an accurate classification to ensure adequate treatment of pancreatic trauma. The latest literature describes surgical, nonsurgical, and minimally invasive ways of treatment. However, for shocked patients with delayed presentation after complete pancreatic neck transection, surgical methods are the first choice treatment. Further studies should be done in the future to set guidelines for surgical and endoscopic treatment and the limitations of each method.

INTRODUCTION

Pancreatic injury is a rare but critical condition with a high mortality rate due to complications including acute bleeding, sepsis, outflow of pancreatic juices into the abdominal cavity, pancreatitis, and the formation of abscesses and fistulas [1]. Today, the most common mechanism of blunt pancreatic injury is a car accident. However, pancreas injuries may occur after various everyday activities such as sports [2,3]. Of all abdominal injuries, the incidence of pancreatic injury is estimated at between 0.2% and 12% [1,4]. The incidence is slightly higher (4,4%) in the case of penetrating abdominal injuries [5]. In about half of the cases, in addition to damage to the

pancreas, there is also damage to some other organ [2,4]. Injury to the pancreas is often overlooked due to late clinical symptoms and is usually suspected only when the clinical picture deteriorates [3]. Elevations of lipase and alpha-amylase may help with diagnostic suspicion to pursue further imaging; one must, however, keep in mind that the elevations are not specific for pancreatic injury. Both enzyme levels are best measured at least 3 - 6 hours after injury [3,6]. Among diagnostic methods today, the most important is CT imaging with a contrast agent, which is usually easily accessible but, unfortunately, sensitive in less than 60% of cases [3,1]. The use of the Endoscopic retrograde cholangiopancreatography (ERCP) or Magnetic resonance cholangiopancreatography (MRCP) method for first diagnosis is reliable with sensitivity close to 100%. ERCP offers the advantage of facilitating therapeutic intervention simultaneously with diagnosis. MRCP is non-invasive but requires an experienced team and is described as a first diagnostic method only in some individual clinical cases [3,1].

CASE PRESENTATION

A 43-year-old patient, a former heroin addict, was brought to the emergency room for hematemesis. Three days before his arrival, he was involved in a fight, receiving a severe blow to the abdomen and several hits to the head and chest. Since then, he had cramping pains in his abdomen, most pronounced under both costal arches. When presented in the emergency center, he vomited blood several times and complained about severe pain. He was hemodynamically unstable; the abdomen was tense, silent, and diffusely tender to palpation.

Laboratory diagnostics showed elevated inflammatory parameters (PCT - 3.2 µg / L, Lkci - 31.6 10 ^ 9 / L, CRP - 327.8 mg / L), elevated lipase (15.69 µkat / L) and alpha-amylase (34.7 µcat / L), normocytic anemia (Hb 102 g / L) and moderately pathological values of liver enzymes (gamma-GT - 2.30 µcat / L, AST - 3.25 µcat / L, ALT - 2.57 µcat / L).

Abdominal CT showed signs of ileus and a completely transected parenchyma of the neck of the pancreas. The break area was described as a 5 cm long hypodense lesion in the pancreatic neck's position; the pancreas's tail was edematous. The stomach, duodenum, and jejunum were enormously dilated. Air embolisms were described in the portal venous system (Figure 1).

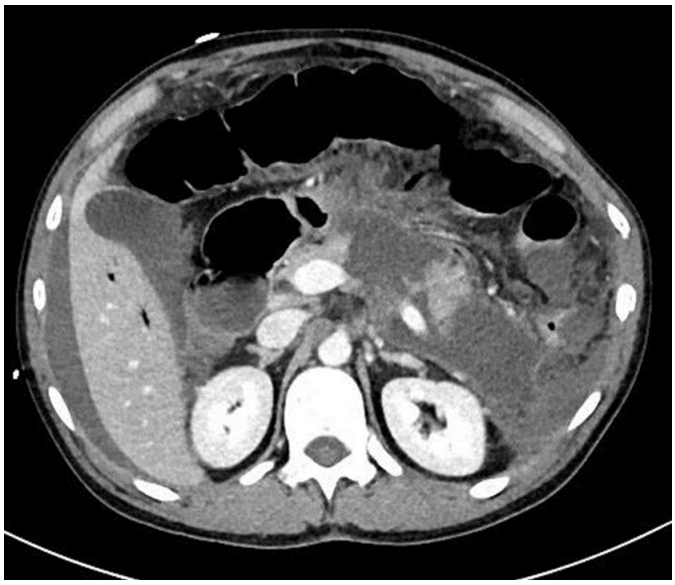

Figure 1. Abdominal CT at presentation, before surgery: A completely transected parenchyma of the neck of the pancreas. The break area was described as a 5 cm long hypodense lesion in the pancreatic neck's position; the pancreas's tail was edematous.

The patient was urgently transferred to the operating room in a state of shock. We approached with upper and middle median laparotomy. As a first step, three liters of sero-hemorrhagic fluid were evacuated from the abdominal cavity. Gastric content was drained retrogradely with the help of a nasogastric tube. We then began the exploration by examining the

entire small and large intestine. No signs of intestinal damage were seen except for steatonecrosis in the mesentery and mesocolon. We entered the bursa through the gastrocolic ligament and exposed a complete transection of the pancreas at the neck level. The splenic artery and vein were intact at the base of the transectional wound. Edema and initial tissue necrosis were present in peripancreatic fat.

We ligated the splenic vessels, first the artery and after the vein, and mobilized the lower and upper edge of the pancreas. The otherwise intact spleen was removed along with the distal pancreas. Before closure, the abdominal cavity was thoroughly washed out with saline. We set up two drains, one on the left and one on the right parapodium.

During the operation, the patient was hemodynamically unstable, receiving infusions of fluid and concentrated erythrocytes. Postoperative treatment was continued in the intensive care unit with antibiotic therapy for 22 days, somatostatin for eight days, proton pump inhibitor, and prophylactic doses of low molecular weight heparin. On the second postoperative day, we initiated parenteral feeding. Blood sugar was within normal limits in all controls, and the patient did not need insulin treatment. He received regular doses of methadone, as in his regular therapy. The need for methadone was transiently increased, which was observed through withdrawal symptoms. CT of the abdomen was repeated two days after presentation and showed fluid collection in the left retroperitoneum, measuring 20 cm x 16 cm x 6 cm. Aerial embolisms in the portal vein system were no longer seen. In the first postoperative week, fluid drainage from the peritoneal cavity was up to 1500 ml of serohemorrhagic content daily. On the 6th day after hospitalization, the patient underwent Endoscopic Retrograde Cholangiopancreatography (ERCP) with papillotomy to facilitate the secretion of pancreatic juices intraluminal. The evaluation of the pancreatic ducts was not successful even after several tries. In the days after the papillotomy, the excretion in the abdominal drains was gradually lower.

Due to persistently silent abdomen and signs of sepsis, a revision, lavage, and drainage flush were performed on day seven after admission. Just before the planned modification, the patient went into respiratory distress due to pneumothorax, most likely caused by fractures of three ribs (IX, X, XI), which were caused by trauma before admission. Thoracic drainage was performed successfully to resolve pneumothorax, and the patient underwent revision without additional complications. Revision and lavage were performed again on the 9th, 14th, and 18th day after admission. Five operations were performed until the amylase, lipase, and inflammatory parameters levels were within normal range, and the abdominal drain color returned to a severe nature (Figure 2).

On the 22nd day after admission, the patient was transferred to the abdominal surgery ward, where he successfully recovered until discharge.

Due to Sars Cov2 infection, hospitalization was prolonged but without major additional complications. CT of the abdomen on the 35th postoperative day from the hospital showed a reduced collection at the tail of the pancreas retroperitoneally (size 10 cm x 2 cm x 2 cm) compared to the previous CT.

During the hospital stay, the patient was tested for hepatitis B, C, and AIDS because he was a former heroin addict. RNA quantitatively for hepatitis C showed a high content (3420000 IU / ml). Given the patient's mildly elevated transaminases, he was given an appointment for a regular check-up by a hepatologist after he was discharged from the hospital.

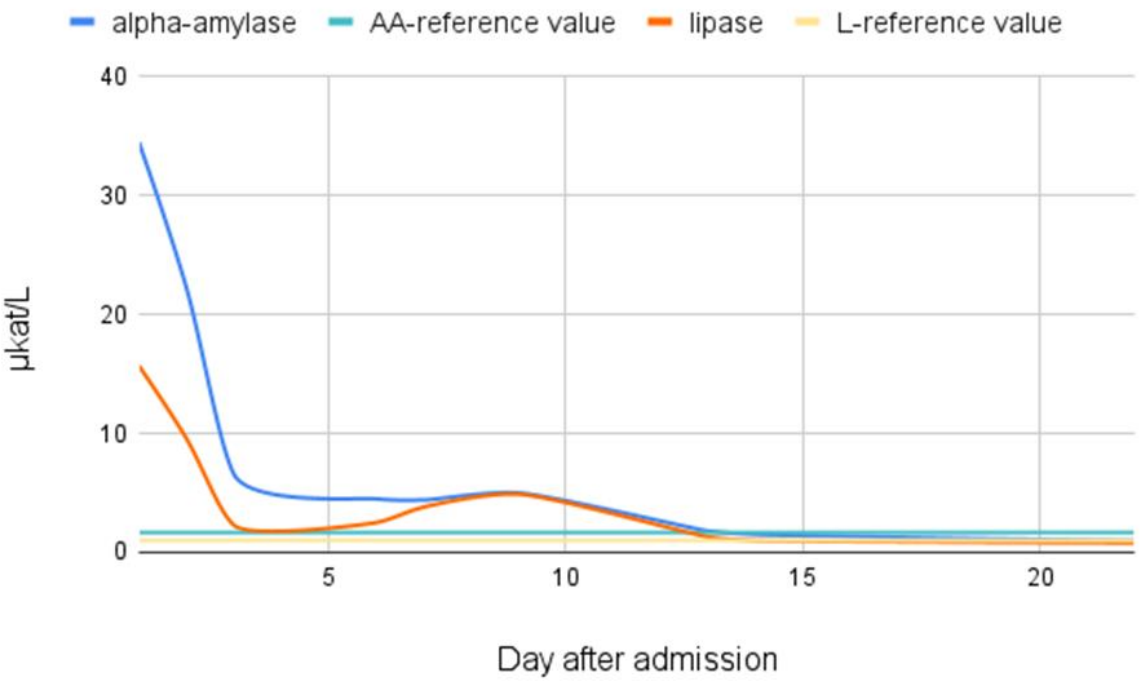

Figure 2. Measured values of alpha-amylase and lipase: Both values decreased steeply after distal pancreatectomy with splenectomy. (AA=alpha-amylase, L=lipase)

DISCUSSION

Blunt abdominal trauma can cause pancreas injury that ranges from mild contusion to complete transection with ductal disruption. The overall incidence of pancreatic injury in abdominal trauma is relatively low and is estimated between 0,2% and 12% [1,4]. The identification can be challenging due to nonspecific symptoms and low specificity of CT imaging for pancreatic duct injuries and can cause delayed diagnosis [5]. Delayed diagnosis drastically decreases the chances of a good outcome, especially in case of ductal injury [12]. After setting a diagnosis of pancreatic injury, staging of injury has to be done to continue with the most optimal treatment [7].

Treatment of isolated pancreatic injury

In 1990, the American Association for the Surgery of Trauma (AAST) introduced a grading system that is still used nowadays. In that classification system, higher-grade injuries correlate with higher mortality and complications (Table 1). It also allows correlation with other organ injury scales [7].

	Table 1. AAST classification of pancreatic trauma [7].
I	**Minor contusion or superficial laceration without ductal injury**
II	**Significant contusion or laceration without ductal injury or tissue loss**
III	**Distal transection or pancreatic parenchymal injury with ductal injury**
IV	**Proximal transection or pancreatic parenchymal injury involving the ampulla**
V	**Massive disruption of the pancreatic head**

Management of a patient with pancreatic injury must follow the Advanced Trauma Life Support (ATLS) guidelines, and damage control operation

is sometimes necessary even before further imaging studies [2]. Indications for immediate operative treatment are hypotension, peritonitis at physical examination, and a positive sign for abdominal fluid at Point Of Care Ultrasound (POCUS) [6]. Staging of injury should be, in that case, done during the initial explorative laparotomy [2, 7].

Surgical treatment may vary from simple drainage to performing Whipple's procedure. Independent of the procedure performed, drainage is mandatory [8, 9].

Intraoperative examination does not always provide a secure answer to whether ductal injury is present or not. External drainage works well in either case scenario [9]. Furthermore, simple drainage is favorable to lengthy, complex procedures with possible further complications in damage control situations [6, 9].

Pancreatic lacerations not involving the duct (AAST grade I and grade II) can be oversewn if the parenchymal bleeding does not stop [2, 6]. One should, however, keep in mind that there is an excellent possibility of necrosis in the area of suture lines. Sewing a piece of viable omentum directly into the laceration is a better option [6].

When diagnosing an injury of the central pancreatic duct, the position of rupture and associated injuries are essential for further choice of surgical technique. AAST grade III and IV injuries are divided by the location of the transection, left (grade III), or right (grade IV) of the superior mesenteric vessels. While Roux-en-Y pancreaticojejunostomy is often discussed in the literature, this approach is very rarely used by surgeons [6, 9]. The safer (but also more tissue-consuming) definitive option for injury types of AAST grade III is the closure of the proximal stump, followed by resecting the distal pancreas with or without splenectomy [2, 6, 9]. Ideally, an attempt to avoid splenectomy should be considered, but this is not often feasible in multiple injured patients [6]. The transection located to the right from superior mesenteric vessels (AAST grade IV) requires approximately 75% to 80% of the pancreas to be resected, which could result in diabetes mellitus. Therefore, Roux-en-Y pancreaticojejunostomy might be an appropriate method to preserve pancreatic tissue, but only when the patient is hemodynamically stable [6].

Extensive trauma to the head of the pancreas usually creates combined pancreaticoduodenal injuries [6]. A trauma Whipple is the ultimate big whack of pancreatic trauma. It is only advised when the damage has already done most of the dissecting for the surgeon (AAST grade V), and the patient is stable enough to survive the operation [9]. The most lethal type of abdominal trauma is centered at the head of the pancreas and is also called a wounded surgical soul. The most significant danger for the patient, in that case, is not a pancreatic leak but an acute hemorrhage from the vascular anatomy of the area [9].

Pancreatic ductal injury can be managed by operation or endoscopic intervention, depending on the type of injury. Endoscopic treatment is being increasingly considered and employed as a surgery-sparing intervention [10]. Søreide and coworkers proposed a simple management outline for pancreatic injury in 2015 whereby surgical, nonsurgical, and minimally invasive treatments are taken into account [3]. Unfortunately, in some centers, the last modality is not readily available in emergencies.

In case of central duct injury with an open proximal stump, a bridging stent can be placed endoscopically in the lesion area. When the patient with pancreatic ductal injury also has a significant traumatic injury to the brain or other severe injuries, endoscopically placed stents can be used as a first choice method to avoid complex operative repair [6]. If the duct in the proximal stump is closed, the endoscopist can convert it to

an open one and manage the same, as explained before. The second possibility is to leave it closed and place a transmural drainage from the distal gland into the stomach or intestine (also by endoscopic pancreaticogastrostomy).

Endoscopic nasopancreatic drain (ENPD) can be placed for diagnostic and therapeutic purposes, especially for I-III grade injuries by AAST [10]. In comparison to stenting, ENPD can be flushed to maintain patency of the lumen and can not migrate; it can also be used later for a control pancreatogram to demonstrate the healing of ductal disruption [11].

In our case, the patient developed only mild symptoms immediately after blunt abdominal trauma. Stronger pain in the abdomen began on the third day after the injury. On admission, he presented with acute hematemesis, tachypnoea, and peritonitis. CT imaging showed a complete transection of the pancreatic neck; blood serum amylase and lipase values were elevated. Urgent operation has also been indicated due to paralytic ileus and deterioration of physiological signs. We have classified the injury as AAST grade III and a distal pancreatectomy with splenectomy has been performed.

In literature, more cases are described with delayed presentation of symptoms after pancreatic transection. If the central duct is injured, there is a strong leakage of pancreatic juice in the abdominal cavity. Pancreatic enzymes are caustic; thus, ductal injury with a leak (≥Grade III by AAST) is the most significant contributor to organ-specific morbidity and mortality [5]. Saponification of fatty tissue causes necrotic lesions and the inflammatory response. Delayed diagnosis and treatment may drastically increase morbidity and mortality [12].

After the operation, endoscopic intervention comes in place when treating postoperative leaks or fistulae. In our case, postoperative ERCP and papillotomy were done to reduce the pancreatic leaks to the abdominal cavity. Moreover, endoscopic stenting of the postoperative proximal pancreatic fistula could have been done to direct the flux of the retroperitoneal collection through the stent into the intestine. This treatment is currently not applicable in our clinic, which might also be problematic for many other clinics. The pancreatic fistula was nevertheless successfully cured by a more invasive surgical approach with drainage and lavages.

We describe many complications during the rehabilitation of our patient: pneumothorax, moderate withdrawal syndrome from opioids, hepatitis C infection, and lastly, Covid 19 infection, which have been successfully resolved and may help the reader to cope with similar clinical situations.

CONCLUSION

Although most pancreatic injuries are detected intraoperatively, it is essential to have an accurate classification, even if this is established at laparotomy, to ensure adequate treatment of the pancreatic trauma or any other associated injury.

We have shown that distal pancreatectomy with splenectomy is still a safe and first-choice method for shocked patients with delayed presentation after complete pancreatic neck transection.

Our opinion is that endoscopic treatment has a vital role in treating postoperative fistulas and leaks, but the surgical approach remains the safer method for pancreatic ductal injury, especially with unstable patients. However, further studies should be done to set guidelines for surgical and endoscopic treatment to determine whether and when endoscopic treatment can be used as a first choice and when as a supportive approach to surgery.

ABBREVIATIONS

CT - Computed Tomography

ERCP - Endoscopic retrograde cholangiopancreatography

MRCP - Magnetic resonance cholangiopancreatography

PCT - Procalcitonin

CRP - C-reactive protein

RNA - Ribonucleic acid

AAST - American Association for the Surgery of Trauma

POCUS - Point-of-care ultrasound

ENPD - Endoscopic nasopancreatic drain

STATEMENTS AND DECLARATIONS

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Case report

Incidental non-traumatic right-sided diaphragmatic hernia during the attempt of laparoscopic cholecystectomy due to symptomatic gallstones – Case report and literature review

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Abstract

We present a case of a 76-year-old female patient who underwent an attempt at laparoscopic cholecystectomy due to symptomatic cholecystolithiasis. At laparoscopy, a right-sided diaphragmic hernia was discovered, and conversion to open surgery was performed. After the reduction of herniated liver and gallbladder, a cholecystectomy was performed. The diaphragmic hernia was repaired with direct sutures. An adult right-sided hernia is a rare condition. Most are treated in emergency settings when they become symptomatic. Treatment includes the reduction of herniated organs, their evaluation and repair, and closure of the diaphragm defect. No guidelines are available for the best treatment approach.

INTRODUCTION

Diaphragmic hernias can be congenital or secondary due to trauma allowing herniation of abdominal content into the thoracic cavity. They are classified into posterolateral, anterior, or central. Posterolateral diaphragmic hernia or Bochdalek hernia was first described by anatomist Vincent Alexander Bochdalek in 1848, while the first successful surgical repair was performed in 1964 [1]. The hernia is formed by the failure to close the pleuroperitoneal canal in the posterolateral part of the diaphragm [2].

The estimated prevalence of Bochdalek hernia varies between 0.17% and 6%, and most reports

suggest they are more common on the left side (80-90%) [2–4]. The higher incidence is thought to be due to faster pleuroperitoneal canal closure on the right and the protective effect of the liver [5]. However, a study of many abdominal CT scans showed a higher right-sided prevalence [3]. The difference might be due to the protective effect of the liver, resulting in asymptomatic patients.

Most right-sided diaphragmic hernias are asymptomatic or presenting with gastrointestinal or respiratory symptoms. Less than 50 cases of right-sided Bochdalek hernias in adults are reported in the literature. Most are found and treated in an emergency setting.

In this case report, we are presenting a 76-year-old woman who was operated on in our department due to symptomatic cholecystolithiasis. Intraoperatively, a right-sided diaphragmatic hernia was found. An open cholecystectomy with hernioplasty of the diaphragmatic hernia was performed.

CASE REPORT

A 76-year-old female patient with known chronic atrial fibrillation, hypertension with apixaban therapy, and chronic heart failure, after an operation of a brain aneurism and mastectomy due to breast cancer was hospitalized in the gastroenterology department after she presented to the emergency room with right upper quadrant pain and vomiting. She had known cholecystolithiasis and was hospitalized 5-months prior due to acute biliary pancreatitis. She was scheduled for an elective cholecystectomy in a different institution.

In the emergency room, lab work showed high values of bilirubin (64/39 µmol/L), ALP of 1.99 µkat/L, GGT 2.27 µkat/L, AST 7.87 µkat/L, ALT 5.39 µkat/L, hemogram and electrolyte values were normal, CRP was 5. A transabdominal US was performed that showed a non-distended gallbladder filled with many small gallstones (up to 7 mm in size) and tick fluid, no changes in the gallbladder wall, no changes in peri choledochal fatty tissue, no free fluid around the gallbladder was seen and no lesions in the liver. No dilatation of the intrahepatic, choledochal, and pancreatic ducts was seen. A high right hemidiaphragm that decreased the visibility of the liver was noted. An endoscopic ultrasound showed a standard choledochal duct with no gallstones to further rule out choledocholithiasis. Neither investigation demonstrated a diaphragmatic hernia.

Due to a history of pancreatitis and reoccurring symptoms, she was transferred to our department for cholecystectomy.

A laparoscopic approach was used for the planned cholecystectomy. Inspection of the abdominal cavity showed a right diaphragmic hernia through which the right lobe of the liver and the gallbladder herniated into the thoracic cavity. After this finding, a thoracic surgeon was consulted to plan the best approach. A conversion to open cholecystectomy through a right-sided subcostal incision was then performed. For the successful repositioning of the liver into the abdominal cavity, an incision to enlarge the hernia was necessary. After further mobilization of the liver, repositioning of the liver and the fixation of the falciform ligament to the abdominal wall were performed. A hernioplasty of the diaphragmatic hernia with interrupted non-absorbable braided sutures followed that. A top-down cholecystectomy was then performed with no complication. An abdominal drain was placed in the gallbladder bed, and the laparotomy was closed.

On the second postoperative day, a pleural effusion was seen on a chest X-ray with a possible right-sided pneumothorax. The patient received diuretic therapy and respiratory physiotherapy. On the third postoperative day, a right thoracic drainage was placed. It was removed after three days. A control chest x-ray showed a small

remaining pleural effusion on the right side. Since the anticoagulation therapy had already been restarted, pleural punction was not performed. The rest of the hospitalization was uneventful. She was discharged on the ninth postoperative day.

The patient had a check-up two weeks after discharge. She reported acid reflux, for which she was prescribed proton pump inhibitors. The control chest x-ray showed a small pleural effusion in resorption on the right. No further check-ups were performed.

DISCUSSION

Nontraumatic right-sided diaphragmatic hernias in adults are uncommon and are usually diagnosed and treated in an emergency setting. In our case, the hernia was discovered accidentally during a planned laparoscopic cholecystectomy. To our knowledge, the patient had no previously known symptoms from the hernia. Patients with symptomatic hernias most commonly present with dyspnoea or abdominal pain [6]. Other symptoms reported are chest and shoulder pain, cough, and symptoms of obstruction (nausea, vomiting, and distension) [7]. The presentation is dependent on the herniated organs and the presence of their strangulation or other pathologies [4].

A recent systematic review of adult nontraumatic right-sided hernias reported that in 52% of reported cases, the colon was herniated in 43% of the small bowel, 27% of the liver, and 18% of the kidney [6]. In our case, the hernia included the liver and gallbladder. The review reports only two other cases where herniation of both liver and gallbladder is described in an adult right-sided diaphragmatic hernia. Baek et al. report a patient who was admitted due to severe acute abdominal pain with signs of perforated peptic ulcer. A CT scan showed intrathoracic displacement of the liver, gallbladder, transverse colon, and omentum through a correct diaphragmatic defect. Intraoperatively, a duodenal ulcer perforation was found and primarily repaired. After reducing the organs, the diaphragmatic defect was closed using a polytetrafluoroethylene patch [8]. A report by Deb et al. describes a patient with a known Bochdalek hernia that presented with nausea and epigastric pain. A CT scan showed multiple visceral herniated into the right thorax, including the bowel. He was operated on with the presumptive diagnosis of bowel incarceration. Intraoperatively, acute cholecystitis of the displaced gallbladder was found. Cholecystectomy and a diaphragm reconstruction with expanded polytetrafluoroethylene were performed [9].

The golden standard for diagnosis is a CT scan [6]. It provides information about the diaphragm defect, hernia contents, and possible herniated organ pathologies [10]. If the diagnosis remains unclear, magnetic resonance imaging can be considered [4]. A chest radiograph may show abnormal contents above the diaphragm; however, it is hard to diagnose a hernia on a chest x-ray [11]. Similarly, in our case, only an elevation of the right hemidiaphragm was noted by a radiologist on a preoperative chest x-ray, and the same observation was noted in a transabdominal ultrasound performed in the emergency room. An abdominal ultrasound examination is suggested as a diagnostic tool to characterize an elevated hemidiaphragm in children further. However, it is not the method of choice in adults [12].

There are no guidelines available on the best treatment approach. Most symptomatic adult right-sided hernias require surgical treatment [6]. However, a wait-and-see approach can be used when the hernia is asymptomatic [13]. Reducing herniated organs and closing the diaphragm defect is necessary when treating them. Transthoracic, transabdominal, or a combined approach can be used. Some authors also suggest a minimally invasive approach. It is useful particularly in an elective setting independent of the size or contents of the hernia, while open

surgery is more appropriate in an emergency setting [7]. Benefits of a transabdominal approach include observing perfusion defects, managing visceral complications and injuries, and intra-abdominal manipulation of reduced organs [14]. It also allows the visualization of the correct position of the viscera and the repair of malrotations [15]. However, it does not allow the exposure of the thoracic cavity and possible management of complications such as pneumothorax, pleural effusion, or empyema [16]. A transthoracic approach also allows entirely unobstructed visualization of the hernia orifice without the need for organ mobilization [17]. Push-back organs are also less harmful when no incarceration is present. [16]. A thoracoabdominal approach combines both benefits but should only be performed if necessary and, if possible, partially minimally invasive [6]. In our case, the hernia was treated surgically through a transabdominal approach as part of the primary laparoscopic cholecystectomy with conversion. The best approach must be chosen individually based on the patient's presentation.

In our case, the hernia defect was repaired with direct diaphragmatic sutures. The use of absorbable sutures reduces the infection risk, while the non-absorbable decreases the number of reoccurrences [18]. Other options reported in the literature include using non-absorbable mesh or a muscle flap [14]. Biologic meshes have been successfully used in diaphragmatic injury repairs(https://doi.org/10.1016/j.ijscr.2012.04.011). However, using a non-absorbable mesh in cases of intrabdominal or intrathoracic contamination is not preferred [6]. They should be used in hernias larger than 5 cm or where the tissue is very brittle [14].

CONCLUSION

We presented a case of successful one-stage surgical treatment of a non-traumatic right-sided diaphragmic hernia that was incidentally discovered intraoperatively during planned laparoscopic cholecystectomy. It is a rare condition usually treated in an emergency setting when they become symptomatic—usually, the symptoms present due to incarceration. When treating them, it is essential to reduce the herniated organs evaluate the viscera, and repair the possible injuries. The defect must be closed fully by either direct sutures, mesh, muscle flap, or a combination of those methods. There are no guidelines for the best treatment approach, which should be decided upon on a case-to-case basis.

STATEMENTS AND DECLARATIONS

Competing Interests: Not applicable.

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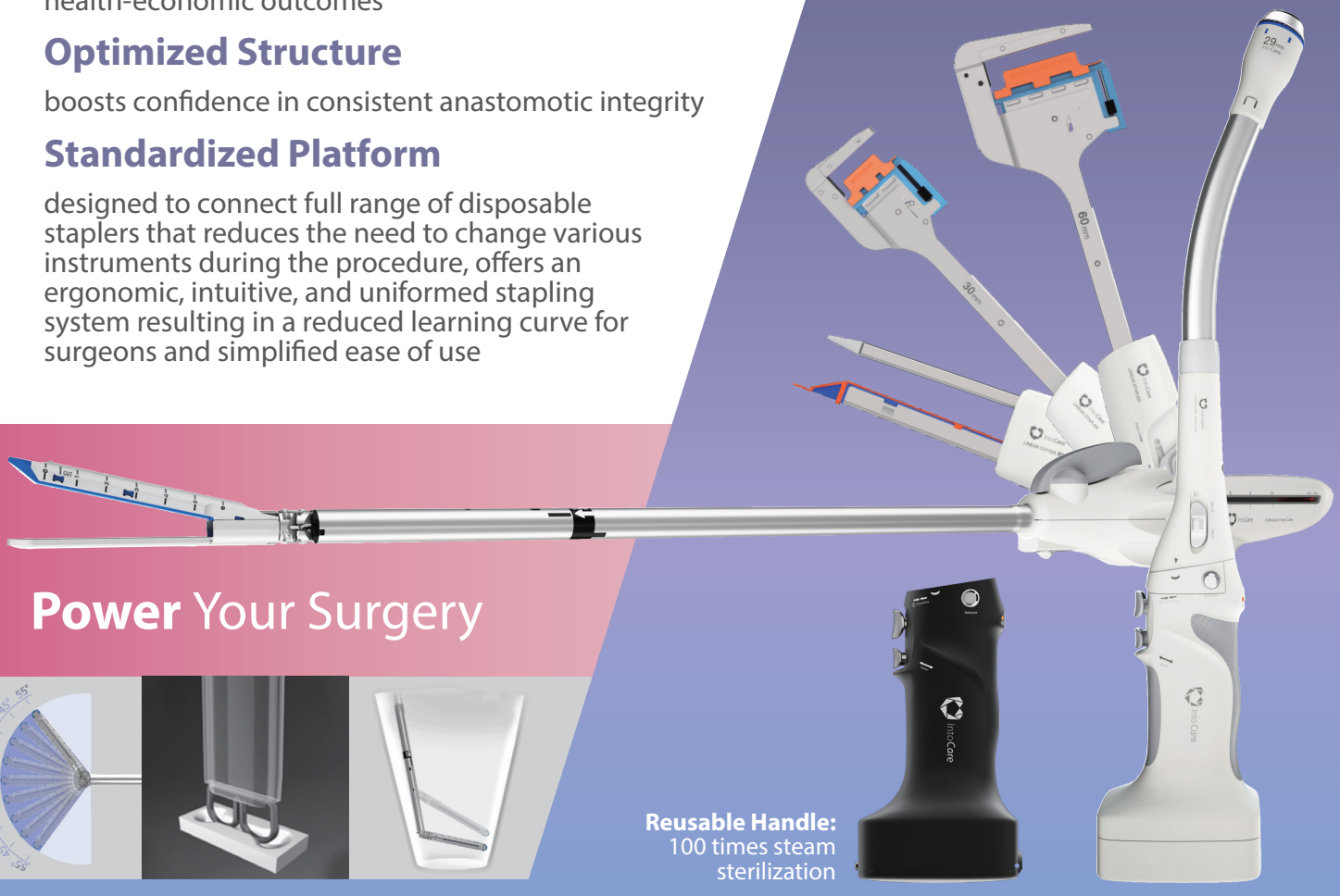

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MEDICA

Surgery and Surgical Endoscopy

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Case report

A rare case of gastric chronic diverticulitis with gastric outlet obstruction

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Abstract

Background: An exceedingly rare condition is an inflammation of gastric diverticula called diverticulitis. We could find only one previous report of diverticulitis. Herein, we present a case report of a 34-year-old woman with gastric outlet obstruction caused by chronically inflamed antral gastric diverticulitis.

Case report: We present a case of a 34-year-old woman with an 18-year history of dyspeptic symptoms with an occasional history of dysphagia. The endoscopy, contrast imaging, and computer tomography studies could not confirm malignancy or other diagnoses. The case was presented on a gastrointestinal multidisciplinary board, where we decided to perform a laparoscopic distal subtotal gastrectomy. The patient underwent a laparoscopic distal subtotal gastrectomy. During the operation, we confirmed that the site of obstruction was the region of the pyloric antrum, which was circumferentially thickened, forming almost a ring.

Conclusion: In patients with early onset of vague upper abdominal discomfort and stenotic changes in the pyloric region after excluding malignant causes of stenosis, it is prudent to have a high index of suspicion for diverticular disease. These might be present even if no openings are seen on endoscopy studies or when contrast studies are negative. We believe that despite potentially present ectopic pancreatic tissue in a diverticulum if no obstruction is present, the patient should be started with PPI therapy and later presented for minimally invasive resection.

December 2023

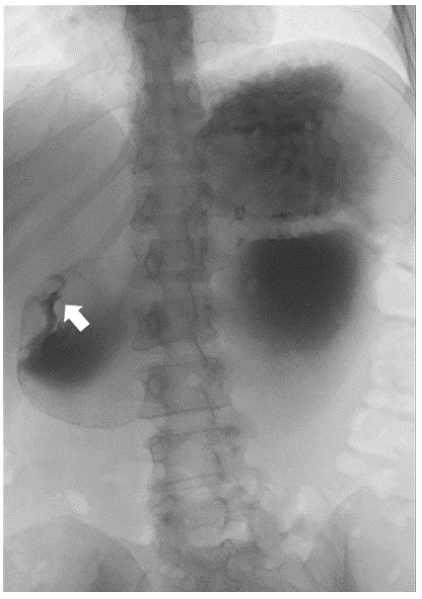
INTRODUCTION

A gastric diverticulum is an outpouching of the gastric wall [1,2,3]. Akerlund and Schmidt have proposed two types of gastric diverticula: i) The true diverticula, consisting of all layers of the gastric wall and is usually congenital, and ii) The false or acquired gastric diverticula [4,5]. The first are usually located in the gastric fundus, while the latter are more commonly found on the posterior wall of the gastric antrum [3,4,5]. Acquired diverticula are also termed tractional since they result from increased intraluminal pressure or traction from intraabdominal adhesions. They are typically associated with chronic coughing, obesity, or pregnancy [3]. They have also been associated with chronic peptic ulcers [3]. Gastric diverticula are a rare condition with a prevalence on autopsy examination of 0.1-2.6% [1,6,7]. If they occur, they are associated with symptoms like upper abdominal discomfort, vague pain, epigastric fulness, bleeding, and perforation [1,2,7,8]. An exceedingly rare condition is an inflammation of gastric diverticula called diverticulitis [9]. We could find only one previous report of gastric diverticulitis [10]. Herein, we present a case report of a 34-year-old woman with gastric outlet obstruction caused by chronically inflamed antral gastric diverticulitis.

CASE REPORT

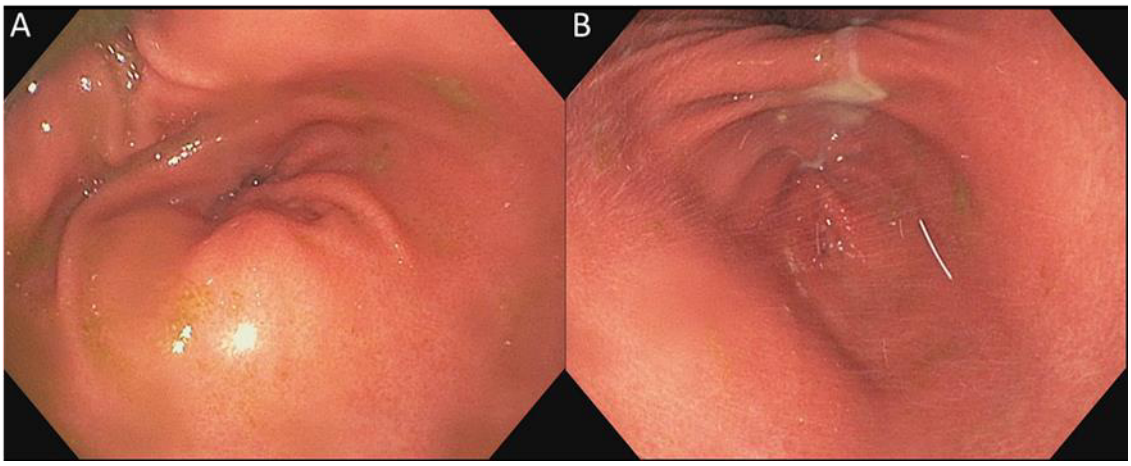
We present a case of a 34-year-old woman with an 18-year history of dyspeptic symptoms with an occasional history of dysphagia. At the age of 16 years, she was first admitted to the hospital for diagnostics of dysphagia. After a course of conservative treatment, she was discharged, but her symptoms recurred two years later. She developed dysphagia and vomiting and was not able to tolerate solid food. She was admitted for diagnostics. An upper gastrointestinal endoscopy was performed, and pyloric stenosis was described. Additionally, a computer tomography with oral contrast was performed. The study confirmed pyloric stenosis with slowed contrast transit into the duodenum. The patient was referred to an abdominal surgeon, who decided to observe the patient due to spontaneous symptomatic resolution. Sixteen years later, the patient again developed symptoms of progressive dysphagia, nausea, vomiting, and involuntary weight loss. On examination, her abdomen was soft, not tender, with mild epigastric distension. Otherwise, she was systemically well. Laboratory investigations were normal. Oral contrast radiographic studies revealed a normal esophagus, no diaphragm hernia, and an enlarged, ptotic stomach, with excessively slow gastric emptying, with a visible thin line of contrast delineating pyloric stenosis of 3-millimeter width (Figure 1).The first upper gastrointestinal endoscopy revealed a dilatated stomach with residual food, a narrow pylorus, that was still passable for the scope. The gastric mucosa and the duodenal mucosa seemed without pathology. Ten specimens of the mucosa were taken. None contained malignancy, and a moderate chronic inflammation with intestinal metaplasia and atrophy was found (Figure 2).

Figure 1. Upper gastrointestinal contrast study.



White arrow: Point of stenosis. A 3 mm narrow trace of contrast with slow transi tof contrast in the pyloric region.

Figure 2. The first upper gastrointestinal endoscopy.



A: a bulging is visible in the preapyloric region; B: the pylorc opening is narrowed

Figure 3. Computer tomography.

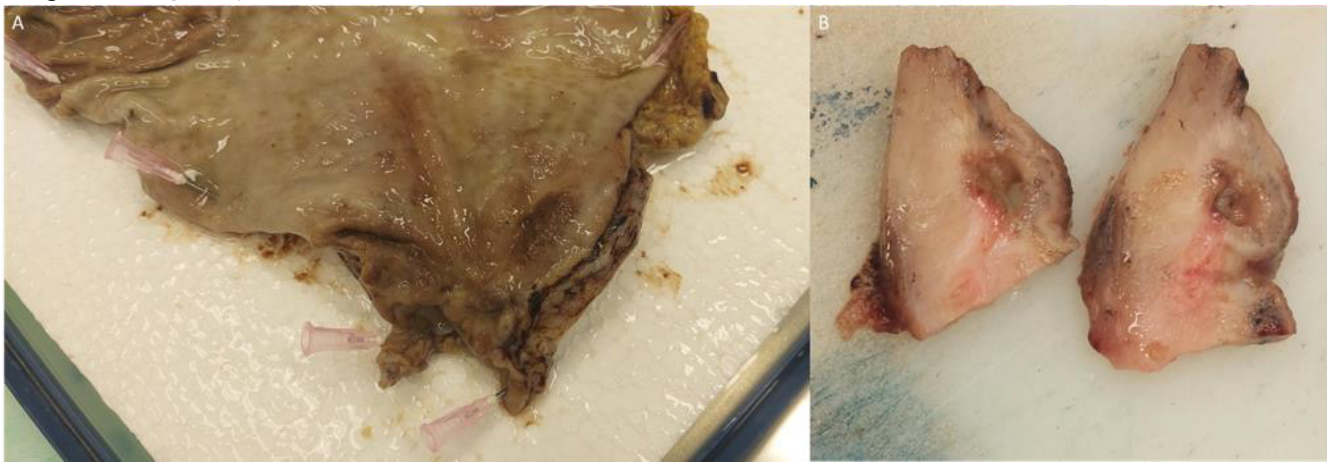
A: Black arrow: Enlarged stomach; B: White arrow: Point of stenosis in the pyloric region; White asterisk: Thickened pyloric wall

The computer tomography scans showed an enlarged stomach filled with liquid, with non-thickened stomach walls. In the pylorus region, a thickened wall of the proximal duodenum/duodenal bulb was described (19 millimeters) (Figure 3). She was put on nil per mouth, nasogastric suction, and total parenteral nutritional support. She received a course of proton pump inhibitors. After her symptoms of nausea and abdominal distension resolved, a second upper gastrointestinal endoscopy was performed to rule out any potential malignancy. There was a complete pyloric stenosis on the second endoscopy, and the passage with the scope into the duodenum was impossible. Histology again ruled out malignancy; only a Helicobacter pylori-negative chronic inflammation was noted (Figure 4).

Figure 4. The second upper gastrointestinal endoscopy.

A: view of the pyloric entry; B: narrowed pylorus; C: duodenum

Figure 5. Surgical specimen



A: longitudinal sections of the specimen; B: circumferential sections

The case was presented on a gastrointestinal multidisciplinary board, where we decided to perform a laparoscopic distal subtotal gastrectomy.

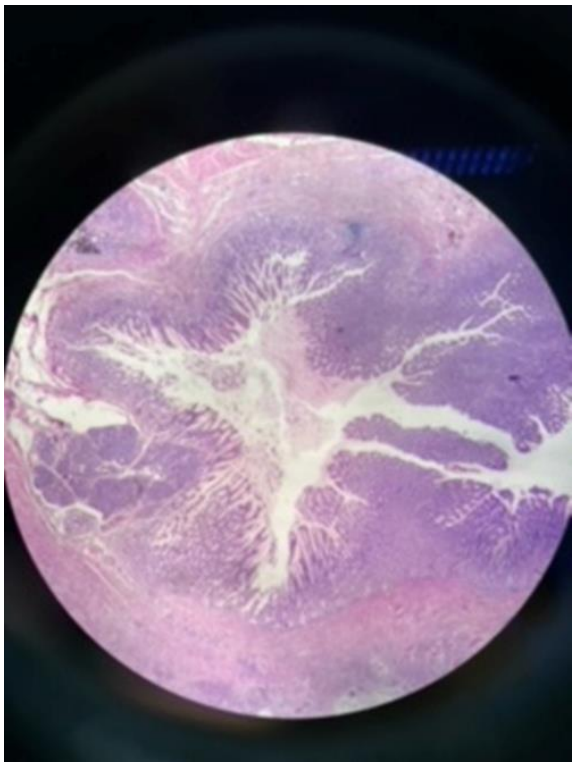
The patient underwent a laparoscopic distal subtotal gastrectomy. During the operation, we confirmed that the site of obstruction was the region of the pyloric antrum, which was circumferentially thickened, forming almost a ring (Figure 5).

She had an uneventful operation and recovery and was dismissed four days after surgery. At

discharge, she was able to tolerate solid food, and she stayed asymptomatic on follow-up three months after surgery.

The microscopic examination of the specimen revealed an antral diverticulum in the pyloric region with signs of diverticulitis and surrounding fibrosis. Ectopic pancreatic tissue was found in the stomach wall of the diverticulum (Figure 6).

Figure 6. Microscopic specimen.



DISCUSSION

Clinicians often fail to diagnose gastric diverticulum as the cause of vague upper gastrointestinal symptoms due to its rare incidence [3,10,11]. Even more importantly, Palmer has reported that endoscopic studies might miss diverticular disease because the gastric opening might not be evident on lateral views in up to five percent of cases [12]. Often, the diagnosis is not made until after symptoms have developed. In this paper, we present a case where a patient had been experiencing symptoms for a prolonged period and had undergone multiple endoscopies, which all yielded negative results. Although the endoscopists noticed a narrowing in the patient's pyloric channel early on, they did not consider the possibility of gastric diverticular disease. Only after the patient developed symptomatic gastric outlet obstruction, necessitating operative treatment, the diagnosis was confirmed with histology.

The main dilemma when facing such a patient is that in addition to the rarity of this condition, upper gastrointestinal endoscopy can be normal in many cases [3,8,12]. Fundal diverticula are more common and have a visible opening, making a diagnosis more straightforward [13]. The false antral diverticula, on the other hand, are more challenging to diagnose [3]. The false diverticula have narrow and hard-to-distinguish openings, which were, in the present case, probably obliterated by chronic inflammation. This caused an annular thickening of the gastric wall, as usually seen in sigmoid colon diverticulitis. Even radiological contrast studies cannot distinguish a diverticular opening in these cases. When clinicians are confronted with a thickened gastric wall, malignancy is the first and most important diagnosis to exclude. In these cases, neither computer tomography nor endoscopy can make the correct diagnosis, leaving the only option of resection. One could argue that a malignant pathology is less probable because of the early onset of symptoms, and a gastric bypass would be a less invasive option. However, it should be noted that the patient was an adult at the second presentation, at which age gastric carcinoma was also possible.

The laparoscopic subtotal gastrectomy is safe, offers a minimally invasive approach, and is an ideal therapeutic option for the treatment of nonmalignant pathology. In the present case, the patient recovered uneventfully and was discharged after four days. Histology confirmed gastric diverticulitis with ectopic pancreatic mucosa in the

diverticulum. We believe that this is the best possible therapy for antral diverticulitis. Usually, gastric diverticula are treated with laparoscopic wedge resection [14]. However, wedge resection can be safely performed only in fundal diverticula, while this is not possible in atrial diverticulitis.

Expectative treatment for antral diverticulitis without stenosis is also an option described by Brian et al. [15]. However, in the present case, the presence of pancreatic tissue in the diverticulum makes the long-term success of proton pump inhibitor therapy highly unlikely. Whether the patient would benefit from an earlier laparoscopic antrectomy could be questioned, but the lack of diverticular openings prevented confirming the diagnosis. In addition, it is arguable whether a biopsy and preoperative confirmation of pancreatic ectopic tissue could have been established earlier. Given all these factors, we believe that even in cases of acquired antral diverticula containing ectopic pancreatic tissue causing chronic inflammation presenting in an adolescent, the best option is to start with conservative treatment and postpone a resection until a later age when symptoms are more pronounced. Thereby avoiding a potentially dangerous procedure with possible functional consequences in an adolescent.

We recommend that in patients with early onset of vague upper abdominal discomfort or stenotic changes in the pyloric region after excluding malignant causes of stenosis, it is prudent to have a high index of suspicion for diverticular disease. These might be present even if no openings are seen on endoscopy studies or when contrast studies are negative. We believe that despite potentially present ectopic pancreatic tissue in a diverticulum when no obstruction is present, the patient should be started with proton pump inhibitor therapy and later presented for minimally invasive resection.

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Review article

Covering of diabetic foot ulcers with local flaps: a review of the literature

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Abstract

Diabetes is a severe chronic disease that affects about 415 million people globally. The most common complication of diabetes is diabetic foot ulceration, which increases the risk of lower leg amputation by a factor of 8. A multidisciplinary approach to limb-sparing has been developed to avoid such catastrophic consequences. The purpose of this review article was to present the possible surgical reconstructive options for covering diabetic foot ulcers with local flaps. Many different reconstructive modalities are described in the literature and are based on the complexity and size of the defect and comorbidities of the patient. Local flaps, exceptionally muscle flaps, provide a good, vascularized tissue cover and produce a lower 5-year mortality rate and economic cost than limb amputation.

INTRODUCTION

Diabetes is a severe chronic disease that affects about 415 million people globally, which accounts for 1 in 11 people [1]. The most common complication of diabetes is diabetic foot ulceration [2]. Diabetic foot means changes that form on the foot of the diabetic patient and are a consequence of diabetes (polyneuropathy or angiopathy or both) [3]. The primary pathogenesis of diabetic foot ulceration involves ischemia, neuropathy, infection, and the addition of external trauma, peripheral edema, and foot deformity [4]. Based on Meklav et al., 20% of patients with diabetes in Slovenia have diabetic foot changes [3]. The numbers are slightly lower than the global population, around 25% [2,5]. The main problem of diabetic ulcers is that once they develop, the risk of lower leg amputation increases by a factor of 8, according to the statistics given in the United States [4]. In the United States, diabetic foot wounds lead to 71000 limb amputations annually [6].

To avoid such catastrophic consequences, a multidisciplinary approach has been developed. It

comprises an endocrinologist, cardiologist, infectious disease specialist, nutritionist, interventional radiologist, wound care nurse, vascular surgeon, orthopedic surgeon, and plastic surgeon [4,7]. If there was a trend in amputating a nonhealing ulcer, the management nowadays has shifted to limb salvaging operations [4]. Foot-sparing reconstructive procedures have become fundamental strategies for limb preservation [8].

The purpose of this review article is to present the possible surgical reconstructive options for covering diabetic foot ulcers with local flaps. When limb amputation is not an option, and when free flaps or skin grafts are not the best choice. We performed electronic searches in PubMed and Ovid's databases based on covering diabetic foot ulcers with local flaps. We included review articles, research articles, and case reports. We used English and Slovenian literature.

THE DIABETIC FOOT RECONSTRUCTIVE PYRAMID

As I said before, treatment of diabetic foot ulcers must be multidisciplinary. When considering diabetic foot reconstruction, there are multiple problems to be addressed. First, we must address systemic aspects of diabetes, then vascular pathology of the patient, neuropathy, and bone deformities [4]. All soft-tissue reconstructive procedures must be delayed until the patient is medically optimized and the infection is clinically eradicated [4,7].

The first step is to establish a clean wound base, which can be done with radical debridement of all necrotic and nonviable tissue and negative-wound pressure therapy (NWPT) or just debridement and covering [2,4,6,8,9]. NPWT cannot be used over untreated osteomyelitis, necrotic eschar, and exposed vasculature [9]. Once we have a clean wound base and reasonable vascular perfusion, reconstruction can be considered using a reconstructive ladder or pyramid [4,8,9,10]. The reconstructive ladder/ pyramid consists of primary closure/ NPWT, skin grafting/ bioengineered tissue alternatives (e.g., Integra, Matriderm, Alloderm)/ local random flaps, pedicle flaps/ local muscle flaps and free flaps [8,9].

LOCAL FLAPS

Local flaps can be divided into local random flaps, local muscle flaps, and local pedicle flaps [7,11].

Local random flaps

Local random flaps are vascularized by a random intradermal or subdermal vascular plexus from a cutaneous, musculocutaneous, or septocutaneous perforating artery. In [6,7,10,12,] Colen et al. 1988 concluded the first case series using local random flaps for diabetic foot reconstruction [10,13]. They help cover diabetic wounds with exposed bone, tendon, or other vital structures on the plantar or dorsal surfaces and replace them with similar tissue without donor-side morbidity [9-11]. We can divide them into rotational, advancement, transposition, bilobed, rhomboid, and toe fillet flaps [7,9,10,12,14,15]. Epidermis, dermis, and subcutaneous tissue, sometimes also underlying fascia, can be included in the flap [6,12]. When planning a local random flap, a length-to-width ratio should not exceed 1:1 or 1:1.5 ratio and can be used to cover defects up to 4 cm2 [16]. Wound dehiscence and scarring are the most common complications in treating diabetic wounds; based on Crystal et al. [10]. Postoperative patients are advised in non-weight bearing, which can also be achieved by placing a cast or an Ilizarov external fixator [7,11].

The rotation flap is mainly used on the plantar side of the foot, especially for midfoot wounds, and can be subfascial or subfascial [6,12,17]. It can also be used on the dorsum of the foot and both malleoli [6].

The advancement flaps are a great option for closing wounds on the plantar aspect of the forefoot [6,11,12,13,18]. They are usually planned in

a VY fashion, can be raised superficially with preservation of sensation and can be advanced 1 – 2 centimeters (cm) [6,11,12].

Transposition flaps can be used to cover more significant defects on the plantar hindfoot. They are based on a rectangular design and require split–thickness skin grafts to cover donor-side defects [12].

For regions with more skin mobility, usually the forefoot region under metatarsal bones, bilobed flaps can be used. Lobes are designed to be 90 degrees from the defect and each other and can cover defects from 1-3 square cm [12,19].

Forefoot defects can also be covered with rhomboid or Limberg-type flaps. This flap can cover more significant defects and should be raised within the relaxed skin tension lines [12].

The toe fillet flap is the last type of local random flap and is usually used after digit amputation with preservation of the surrounding skin and soft tissue [9,14,15,18].

Local muscle flaps

Local muscle flaps are flaps that have an axial blood supply and are especially good for plantar weight-bearing wounds or osteomyelitis wounds [2]. They were first discovered by Ger et al. in the 1960s [20,21]. The most problematic site for wound covering is the plantar region, which consists of glabrous skin and abundant fat pads, fascia, tendons, and muscles. Muscle flaps are believed to have the best ability to absorb and distribute shearing forces along the foot [20]. Local muscle flaps, in comparison with local fasciocutaneous flaps, bring more revitalized tissue into the defect and more bulkiness and usually do not leave any problematic donor site morbidity [9,12,20]. They can be harvested with just local anesthesia. The only disadvantage is their limited bulk and reach. Limited flap motion range can be increased by ligating the dominant pedicle's feeding artery if there is a good collateral flow [22]. The intrinsic muscle flaps of the foot have one dominant pedicle entering or near the muscle's origin and a minor pedicle entering the muscle more distant [7]. After inserting muscle flaps at the recipient site, we cover them with allogenic or autogenous skin grafts [23]. Postoperative treatment is the same as in local random flaps [7,24].

The most common local muscle flaps are the abductor hallucis, the abductor digiti minimi, the flexor digitorum brevis, and the extensor digitorum brevis [2,7,9,12,23]. We use these muscles because they tend to be atrophic in patients with diabetic neuropathy [12].

- Abductor hallucis flap covers plantar or medial midfoot, forefoot, heel, and ankle defects [9,22,23]. It is supplied by muscular branches of the medial plantar artery, with the dominant pedicle at the take-off of the medial plantar artery. It has a very thin distal muscular bulk, so dissecting from the flexor hallucis brevis muscle can be difficult [6,9].

- Abductor digit minimi (ADM) flap is the major workhorse flap for small to moderate-size defects in the hindfoot, lateral plantar midfoot, lateral ankle, and calcaneal region [6,9,12,20-22]. Its dominant pedicle of the lateral plantar artery is distal and medial to its origin on the calcaneus. ADM flap can also be used in patients without pedal pulses, as Altindas et al. [6,20] described. In some cases, the recipient site can be closed primarily. The flap can also be tunneled from the donor to the recipient site [24]. The only disadvantage of this flap is that it is of a limited size [21].

- The Flexor digitorum brevis (FDB) flap covers plantar heel defects and midfoot. Its vascular supply comes from two major medial and lateral plantar artery pedicles. FDB muscle can cover deep defects because of its significant bulkiness [6,9,12,22,23].

• Extensor digitorum brevis (EDB) flap is based on the lateral tarsal artery, a branch of the dorsal pedis artery. The flap covers sinus tarsi and lateral calcaneus but can also cover the Achilles tendon and malleoli [6,9,12]. We can also use this flap as a rotating flap on the dominant pedicle, lateral tarsal artery, or dorsalis pedis artery. Unfortunately, it has a limited bulkiness. However, because the flap consists of 4 muscle bellies, it can fill bone cavities in osteomyelitis feet [12,25].

Local pedicle flaps

We must think about pedicle flaps when covering larger wounds, more than 4 cm2 [16]. Pedicle flaps can be fasciocutaneous, adipofascial, or musculocutaneous and are defined as tissue areas with a good neurovascular supply. The most common ones used in diabetic foot are the digital artery island flap, medial plantar artery flap, and reverse-flow sural artery flap. One of the advantages of pedicle flaps versus local random or muscle flaps is that they can be harvested outside the weight-bearing zone, so if the flap fails, the original defect is not larger than before [7,12].

• Digital artery island flap is an adipofasciocutaneous flap based on the digital artery, vein, and nerve. The flap is typically raised from the lateral aspect of the great toe or the medial aspect of the fifth toe because the metatarsal arteries here are the longest and provide a larger arc of rotation. The donor site is usually covered with STSG. A digital artery island flap covers defects of the plantar forefoot [6,7,12].

• Medial plantar artery (MPA) flap is a workhorse flap for patients with a soft tissue defect together with Charcot neuroarthropathy. MPA flap consists of the deep or superficial medial plantar artery and a cutaneous branch of a medial plantar nerve. We can repair sensation by carrying the cutaneous branch of a medial plantar nerve. It's a fasciocutaneous flap that can cover defects up to 6x10 cm, mainly used around the dorsal–medial or lateral–plantar midfoot and heel. Blemishes on the donor site are protected with split–thickness skin graft [5-7].

• Reverse flow sural artery flap is a neurofasciocutaneous flap based on the vascular axis of the sural nerve. The flap receives its vascular supply through retrograde flow from communication with the perforating branches of the peroneal artery. The most distal pivot point of the flap is approximately 5 cm proximal from the lateral malleolus [6,12,26]. The flap can be raised supra or subfascially, covering more significant defects around the heel, ankle, and lower leg. The donor site is closed primarily or using the STSG [7,12]. Because the peroneal artery usually occludes later than the anterior or posterior tibial artery, this flap is ideal for patients with diabetic foot ulcers [5]. Based on Yammine et al., venous insufficiency and increasing age are the risk factors for the development of complications and not diabetes [26].

DISCUSSION

Limb amputation, in comparison with limb salving procedures, like local flap coverage and other modalities, leads to higher economic costs and a higher 5-year mortality rate [16]. Therefore, A proactive, multidisciplinary approach is essential for long–lasting, soft–tissue cover for diabetic wounds. Every diabetic wound needs debridement and well-vascularized coverage.

Split-thickness skin grafting (STSG) is a simple and effective procedure to cover wounds with healthy granulation tissue without exposed tendons, bones, vessels, or joints [2,7-9,12]. It also cannot be placed on a weight-bearing surface or subject to shearing forces [9,12,16]. Mostly dorsal and some plantar soft-tissue defects can be effectively managed with STSG as recommended by Ignatiadis et al. and confirmed by Anderson et al [2]. If all the above is not included, we must think about bioengineered tissue or flap coverage.

Regarding the size, we can use local flaps, pedicle flaps, or free flaps. Surgeons must also bear in mind that the cover of a soft tissue defect must be based on the safer flap according to the vascularity of the limb. Local random flaps are beneficial for covering small to medium-sized defects because they can replace soft tissue with adjacent tissue without sacrificing structure and function. Based on Ramanujam et al., local random flaps have an almost 76% successful coverage rate but have a much higher complication rate than local pedicle flaps or free flaps, as was displayed by Kim et al. Wound dehiscence and skin slough are the most common complications, usually treated conservatively [2,10,16].

People still think that flap reconstruction in diabetic patients will not work because of arterial vessel disease. This statement was dismissed by subsequent studies (for example, JP Hong et al., Colen et al., and Ozkan et al.), which showed that arterial occlusive disease occurs mainly in the leg and that the system in the foot is less involved. That is why the microsurgical approach in diabetic foot showed similar success to that of a non-diabetic patient [2,4]. Nevertheless, when considering covering the defect with a free flap, at least the tibial arteries must be revascularized in patients with peripheral arterial disease. A small vessel with a pulsatile flow is enough for free flap anastomosis. Free flaps are mainly indicated for extensive and complex wounds where local tissue is nonviable or inadequate [2,4].

Hong et al., in their study, stated that local flaps have not been as successful as free flaps, especially in diabetic feet with reduced perfusion, because of breaching the distal flow of small collateral vessels [4]. Crystal et al. agreed that diabetic foot ulcers can be closed with local flaps [10]. This was confirmed by Attinger et al. in his study, where he concluded that local muscle flaps provide a simpler, less expensive, and successful alternative to free flaps for small foot and ankle defects with exposed bone (with or without osteomyelitis), tendon or joint [2].

While pedicle fasciocutaneous flaps can cover more extensive wounds, they are inferior to local muscle flaps in treating osteomyelitis, usually leave a problematic donor site, and do not provide enough bulk [22]. Hong et al. found them inferior to free flaps because of their lower success rate [4].

Despite all that, controversy still exists as to which flap, whether local muscle flap with skin graft, fasciocutaneous perforator flap, or free flap, offers the optimal reconstruction method for diabetic foot ulcer. Nevertheless, we can agree that if the defect is covered with well-vascularized tissue, it will provide an optimal cover.

CONCLUSION

Treating diabetic foot ulcers remains a challenging task. If limb amputation was the primary treatment in the past, nowadays, a multidisciplinary approach with limb-sparing reconstructive techniques dominates. There are many options for soft tissue reconstruction in the diabetic foot based on the defect's size, comorbidities, and complexity.

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