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Vascular anatomical considerations in preparing colonic flaps to replace the oesophagus

Amr Abdelhamid AbouZeid

Abstract

Background: The colon is among the best options to substitute the oesophagus; it is well known for its durability and good function that makes it most suitable for paediatric patients. The steps of the procedure, postoperative complications, and outcome assessment were thoroughly discussed in previous reports. However, in this report, we have tried to focus on one basic and essential step of the operation, which is fashioning of the colonic flap used to substitute the oesophagus.

Results: The study included 50 consecutive paediatric cases who underwent colonic replacement of the oesophagus during the period 2010 through 2020. The indication for oesophageal replacement was either oesophageal atresia (27 cases) or corrosive strictures (23 cases). Our standard technique was using a middle segment of the colon (transverse colon) based on the left colic vessels (vascular pedicle) after ligation of middle colic vessels. Variations of the middle colic vessels were encountered that included single, double, or absent vessels. In a single case (2%), the middle colic vessels were multiple, short, and non-branching with interrupted continuity of marginal vessels at that point. In the latter situation, we had to use a different technique by fashioning a right colonic flap based on the middle colic vessels.

Conclusion: In colonic replacement of the oesophagus, preparing a pedicled flap from the transverse colon based on the left colic vessels was almost always feasible owing to the stable collateral marginal vessels. On a rare occasion, the marginal vessels were interrupted by disturbed anatomy of the middle colic vessels when we had to shift to another technique using a right colonic flap.

Keywords: Oesophageal substitution, Oesophageal atresia, Caustic strictures, Colon bypass, Anti-reflux

Background

Long-gap oesophageal atresia and non-dilatable corrosive strictures are the main indications for oesophageal replacement in children [1]. Different centres apply different techniques to replace the oesophagus [2, 3]. The colon is among the best available options to substitute the oesophagus; it is well known for its durability and good function that makes it most suitable for paediatric patients [4]. At our paediatric surgical centre, the colon has almost always been the first and maybe the only choice to substitute the oesophagus since we have started that programme 50 years ago [5, 6].

The colon is characterised by reliable collateral circulation via anatomical vascular communications between its main feeding vessels [7]. The marginal artery of Drummond is one of these collateral vessels and represents the backbone for preparation of a well-vascularised pedicled flap of colonic tissue to substitute the oesophagus. Different segments of the colon (right or left) can be used based on which vessel will be chosen as the vascular pedicle of the flap: left colic, middle, or right colic vessels [8–10]. Also, the orientation of the flap may

Correspondence: amrabdelhamid@hotmail.com
Pediatric Surgery Department, Faculty of Medicine, Ain Shams University, Lotefy El-Sayed street, 9 Ain-Shams University buildings, Abbassia, Cairo 11657, Egypt

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vary whether iso- or anti-peristaltic, although the former is much more common [11, 12].

The complete steps of colonic replacement of the oesophagus, postoperative complications, and outcome assessment were thoroughly discussed in previous reports [13, 14]. However, in this report, we have tried to focus on one basic and essential step of the operation, which is fashioning of the colonic flap used to substitute the oesophagus. Also, we highlighted the significant variations in vascular anatomy of the colon that may face the surgeon during preparation of such colonic flaps.

Methods

This is a retrospective study that included 50 consecutive paediatric cases who underwent colonic replacement of the oesophagus during the period 2010 through 2020. The indication for oesophageal replacement was either oesophageal atresia (27 cases) or corrosive strictures (23 cases). Their age at operation ranged from 7 to 144 months (mean 34; median 22). For each case, the details of preparing the colonic flap to substitute the oesophagus have been documented and summarised by the author through a schematic diagram; these data were available for retrospective analysis.

The standard technique was preparation of an isoperistaltic colonic flap including the transverse colon and based on the left colic vessels (vascular pedicle) after ligation of the middle colic vessels (Fig. 1a, b). Ligation of the middle colic vessels was always performed below its bifurcation into right and left branches in order to preserve blood flow to the proximal (right) side of the flap through the collateral circulation (marginal vessels). Occasionally, more length of the colonic flap was needed to bridge a longer gap (very high oesophageal stricture). In such situation, extra length of colon could be included in the flap by extending ligation to the right colic vessels as well (Fig. 1c).

Results

The anatomy of the left colic vessels was 'more or less' stable in all cases not to cause any obstacles during fashioning of the standard flap. On the other hand, the anatomy of the middle colic vessels showed considerable variations (Table 1). The presence of either a single or double middle colic vessels were the most common variations (23 and 24 cases, respectively) with insignificant effect on surgical decision. In the presence of double middle colic vessels, both were ligated below their bifurcation (Fig. 2). The absence of the middle colic vessels was found to be a rare but favourable variation (2 cases) when the marginal vessels were well developed perfectly running parallel and close to the colonic flap (Fig. 2c). Another significant form of vascular anatomical variation was the level of branching (bifurcation) of the middle colic vessels. Early (proximal) bifurcation is associated with a short vascular stump that requires extreme care during its ligation to avoid occlusion of blood flow through the marginal vessels by the ligature. In a single case (2%), the anatomy of the middle colic vessels was so disturbed to interfere with fashioning of the usual 'standard' transverse colonic flap. The middle colic vessels were multiple, short, and non-branching with interrupted continuity of marginal vessels at that point (Fig. 3). Here, we found it impossible to ligate the middle colic vessels in the standard way, so we shifted to another technique to fashion an isoperistaltic right colonic flap based this time on the middle colic vessels (instead of left colic vessels) after ligation of the right colic vessels (Fig. 3).

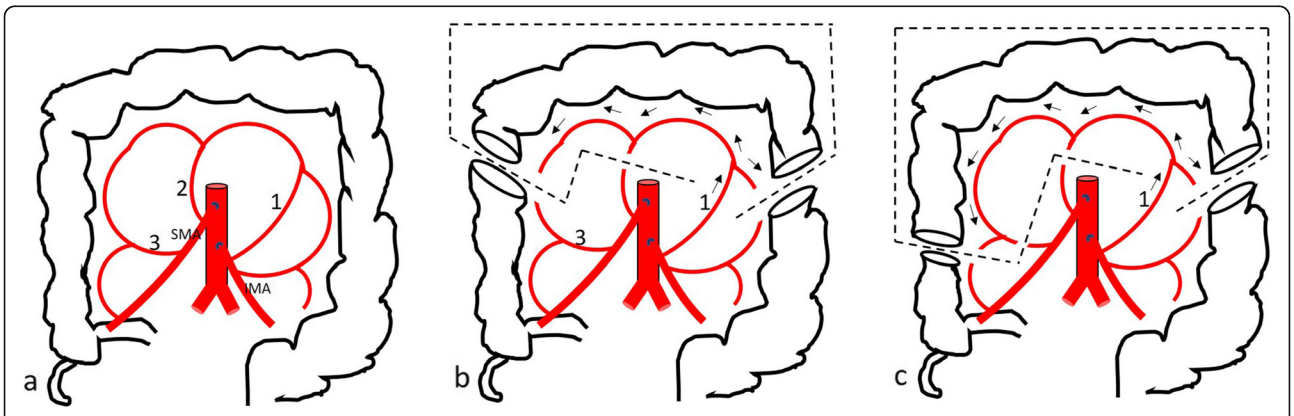

Fig. 1 Technique for fashioning an iso-peristaltic colonic flap including the transverse colon and based on the left colic vessels. **a** Vascular anatomy of the colon: superior mesenteric artery (SMA) giving origin for middle colic (2) and right colic arteries (3), while the inferior mesenteric artery (IMA) gives the left colic artery (1). **b** Boundaries of the colonic flap (dashed line) after ligation of the middle colic vessels. Note: ligation of middle colic vessels should be below its bifurcation to allow blood flow to the right side of the flap through the marginal vessels (arrows). **c** Extra length of colon can be included in the flap by extending ligation to the right colic vessels as well

Table 1 The incidence of the anatomical variations of the middle colic vessels in this case series (50 cases)

Anatomical variations of the middle colic vessels	Number of cases	Percentage
Single middle colic vessels	23 cases	46%
Double middle colic vessels	24 cases	48%
Absent middle colic vessels	2 cases	4%
multiple, short, and non-branching middle colic vessels	1 case	2%

Regarding postoperative complications, our main concern in this report was with the complications related to colonic flap vascularity. Except for partial wound disruption at the neck anastomosis (8 cases, 16%), no major complications related to colonic flap vascularity were detected in this case series; these usually healed spontaneously within two weeks and without delayed consequences [13, 14].

Discussion

Oesophageal replacement procedures are one of the major operations in paediatric surgery. These procedures require high standard of surgical practice in order to minimise complications and morbidity that may be related to the complexity of the procedure [4]. Continuous advancement in neonatal care and new techniques for management of oesophageal atresia and strictures has succeeded in preservation of the native oesophagus in many of these cases with consequent decrease in the indications for replacing the oesophagus [2, 3, 15]. While fewer cases will undergo oesophageal replacement, surgeons become more in need to standardise their techniques [2, 14]. Unfortunately, data available in the literature could not determine the best substitute for the oesophagus [2, 3]. Different centres are reporting on using different techniques with comparable results [4, 11].

At our centre, we have been always using the colon to replace the oesophagus in children [5, 6]. Several modifications have been applied to minimise complications and improve outcome. Although placing the colonic conduit in the posterior mediastinum (colon interposition) has been described as more anatomical [16], yet it may be associated with more morbidity. So, we have mostly shifted to the retro-sternal route (colon bypass) that showed comparable functional outcomes with more smooth postoperative recovery [14]. Also, regurgitation of gastric contents into the colonic conduit was a major source of early and late complications. Transferring the cologastric anastomosis to the posterior wall of the stomach has greatly prevented these complications related to regurgitation [13, 14].

Fashioning of a well-vascularised colonic conduit is the key step for successful replacement of the oesophagus. Our standard technique is using a middle segment of the colon (transverse colon) based on the left colic vessels (vascular pedicle) [13, 14]. Preparing this standard colonic flap was almost always feasible owing

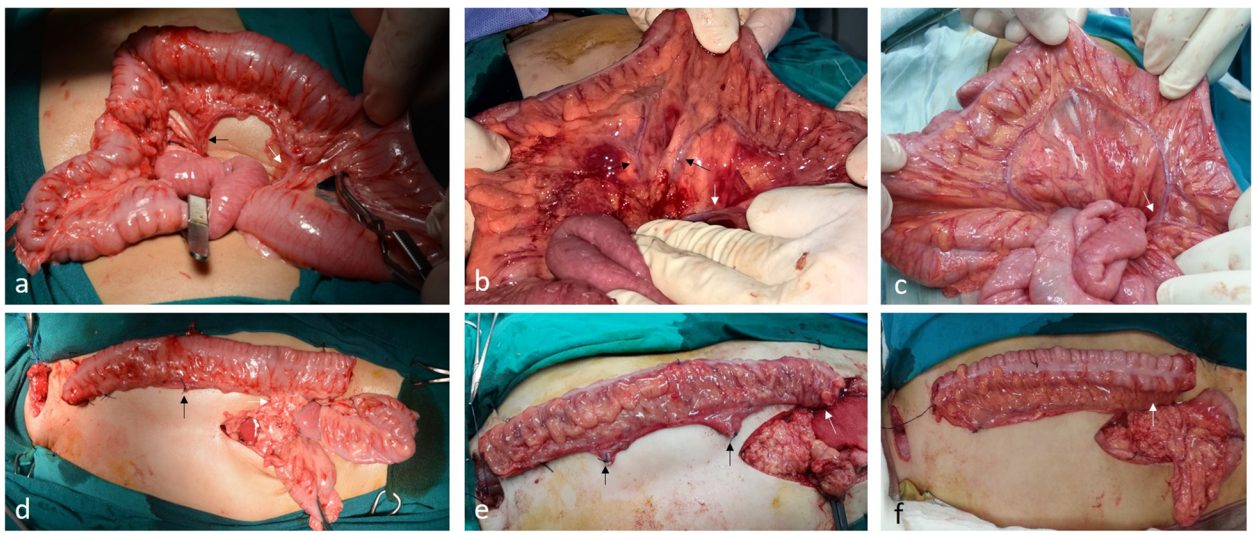

Fig. 2 Anatomical variations of the middle colic vessels. Upper row: the transverse colon in three different cases demonstrating a single, double, and absent middle colic vessel in **a**, **b**, and **c**, respectively. Lower row (**d**, **e**, and **f**): fashioning of transverse colonic flaps based on left colic vessels after ligation of middle colic vessels for the same three cases, respectively. Note: black arrows point to middle colic vessels, while the white arrows point to left colic vessels (flap pedicle)

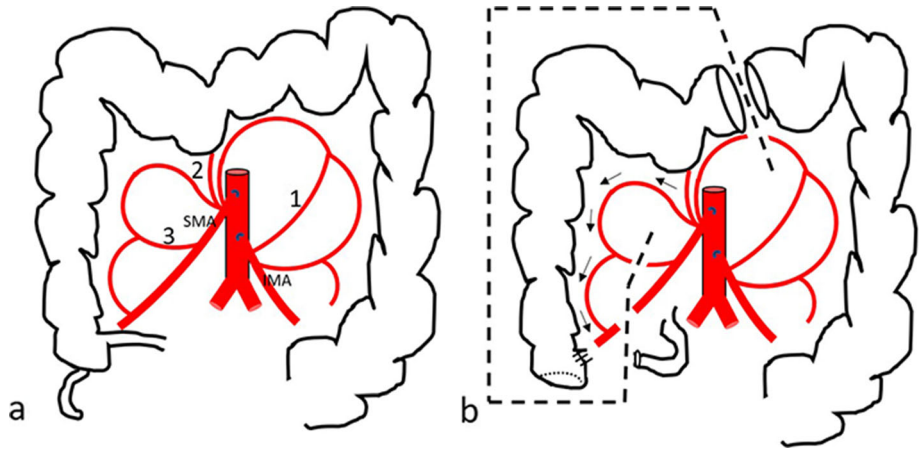

Fig. 3 Diagram demonstrating rare variation in the anatomy of middle colic artery (2%). **a** Superior mesenteric artery (SMA) giving origin for middle colic (2) and right colic arteries (3), while the inferior mesenteric artery (IMA) gives the left colic artery (1). The middle colic vessels (2) were multiple, short, and non-branching with interrupted continuity of marginal vessels at that point. **b** Boundaries of the right colonic flap (dashed line) based on the middle colic vessels after ligation of right colic vessels. Note: the appendix has been removed, followed by separation of the ileo-colic junction, while the gastrointestinal tract continuity will be restored by anastomosing the terminal ileum with the left colon. The dotted line in the cecum is marking for the site of anastomosis with the oesophagus in the neck

to the relative stable vascular anatomy and reliable collateral circulation of the colon (marginal vessels). When needed, extra length can be added to the colonic flap by extending ligation to the right colic vessels in addition to the middle colic vessels. In a single case, the disturbed anatomy of the middle colic vessels represented an unpleasant surprise to the surgical team, when we could not prepare the colonic flap in the usual way. However, knowledge about other ways of fashioning colonic flaps offered a good immediate escape from this difficult surgical situation [8, 9]. Since it was impossible to ligate the middle colic vessels in a way that would preserve the marginal vessels, a flap of the right colon was prepared using the middle colic vessels as the vascular pedicle this time (instead of its ligation). Despite deviation from our standard surgical practice, we did not find major difficulty in the procedure as we were applying the same principles that depend on the marginal vessels to supply the right colonic flap with similar iso-peristaltic orientation. This case had un-eventful recovery and similar good functional outcome.

The presence of more than one technique to replace the oesophagus can represent another chance after failure of a primary procedure [14]. Unfortunately, the limited number of cases and the complexity of the procedure make it difficult for a single centre to master more than one technique [2]. We believe that a major advantage for using the colon to replace the oesophagus is preservation of the stomach which is an essential organ for proper feeding and wellbeing of humans [14]. Here, we may add another advantage for the colon as a substitute for the oesophagus. The availability of different segments of the colon allows for more than one option which can be used in occasional difficult situations related to anatomical variations.

Conclusion

In colonic replacement of the oesophagus, preparing a pedicled flap from the transverse colon based on the left colic vessels was almost always feasible owing to the stable collateral marginal vessels. On a rare occasion, the marginal vessels were interrupted by disturbed anatomy of the middle colic vessels when we had to shift to another technique using a right colonic flap.

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Author's contributions

This manuscript has a single author only. The author read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

A written consent was taken before operation in all cases. Owing to the retrospective nature of the study, an IRB number was not required, and the study was approved through expedited review by the scientific/ethical committee of the Surgery Department (Faculty of Medicine, Ain-Shams University).

Consent for publication

Patient identity did not appear in any part of the manuscript; therefore, consent for publication was not required.

Competing interests
The author declares that there are no competing interests.

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