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Clinical relevance of the arterial supply to the proximal rectum

Nerissa Naidoo[1], Lelika Lazarus[2], Bhugwan Singh[3], Kapil S. Satyapal[2]

[1]College of Medicine, Mohammed Bin Rashid University of Medicine and Health Sciences, Dubai Healthcare City, United Arab Emirates , [2]Department of Clinical Anatomy, School of Laboratory Medicine and Medical Sciences, College of Health Sciences, University of KwaZulu-Natal, Westville Campus, Durban, South Africa, [3]Department of Surgery, School of Clinical Medicine, Nelson R Mandela School of Medicine, College of Health Sciences, University of KwaZulu-Natal, Durban, South Africa

SUMMARY

Although the rectum is considered to be an organ rich in vascularity, the exact role of the middle rectal artery appears to be an area of much debate. Despite its principal supply from the superior rectal artery, there is a lack of information regarding the arterial supply to the fractionized proximal rectal regions. The approach to operative procedures in the case of recto-sigmoid carcinoma, intestinal embolization and haemorrhoidal disease are considered to be largely dependent on the intramural rectal anastomosis.

Since the subsequent outcome of surgical intervention lies in the preservation of the respective rectal arteries, this study aimed to identify the proximal rectal arterial supply and the bilateral presence and/or variation of the middle rectal artery in ten fetal and ten adult cadaveric specimens (n=40).

While the superior rectal artery presented as the principal arterial source to the proximal rectum, the respective regions of the proximal rectum were also found to be supplied by the median sacral and middle rectal arteries.

The inconsistent morphological inconstant nature of the middle rectal artery confirmed that it does not represent the principal arterial source of the proximal rectum; however it was postulated that the middle rectal artery is regularly present in female individuals.

As the regional arterial supply to the proximal rectum was investigated in accordance with appropriate anatomical landmarks, it may also be used to demarcate the specific regions of the proximal rectum. Furthermore, this may assist to preserve the rectal arterial supply during the Hartmann's Procedure.

Key words: Proximal rectum – Arterial supply – Middle rectal artery – Superior rectal artery

Corresponding author: Dr Nerissa Naidoo. College of Medicine, Mohammed Bin Rashid University of Medicine & Health Sciences, P.O. Box: 505055, Dubai Healthcare City, United Arab Emirates. Phone: + 971 505 864 363.

E-mail: nerissa.naidoo@mbru.ac.ae

INTRODUCTION

The rectum is the downward continuation of the sigmoid colon, commencing just anterior to the sacral promontory at vertebral level S3 (Greenfield et al., 2001; Standring et al., 2016). It terminates at the superior end of the anal canal at the level of the levator ani muscle (Greenfield et al., 2001; Standring et al., 2016).

In cases of recto-sigmoid carcinoma, the Hartmann's Procedure allows for the resection of the complete sigmoid colon and the proximal rectum (Dalmia, 2015; Barbieux et al., 2016; Rutegard et al., 2016). While a colostomy bag is initially inserted and attached to the inferior rectal end at the external abdomen on the left side, the reversal of the Hartmann's Procedure is generally done post-operatively when the patient is well-recovered and healthy (Kreis et al., 2012; Dalmia, 2015). This involves the colorectal anastomosis as it links the descending colon with the remaining rectal stump (Barbieux et al., 2016).

Although the rectum has been reported to have an abundant vascular supply, arising principally from the inferior mesenteric and internal iliac arter-

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ies, there is much discussion regarding its actual arterial source (Iqbal et al., 2011; Azimuddin and Raphaeli, 2013).

Ayoub (1978) and Standring et al. (2016) identified the arterial supply to the rectum to be derived from the superior, middle and inferior rectal arteries. Despite the negligible supply from the median sacral artery to the posterior rectal wall; the superior, middle and inferior rectal arteries vascularize the rectum at the superior two-thirds, middle one-third and inferior one-third, respectively (Ayoub, 1978; DiDio et al., 1986; Iqbal et al., 2011). These arteries have been observed to form an intramural anastomotic network within the distal rectum (Greenfield et al., 2001; Iqbal et al., 2011).

In addition to the origin site of the superior rectal artery, the inferior mesenteric artery descends from the abdominal aorta to also give rise to a number of sigmoid branches which supply the sigmoid colon and give the appearance of an arterial cascade (Murono et al., 2015). However, during the Hartmann's procedure, the sigmoid branches and superior rectal artery are often damaged or accidentally removed (Kreis et al., 2012; Rutegard et al., 2016). Upon reversal of the Hartmann's Procedure, there is atrophy of the remaining rectal stump, which the clinician has attributed to a deficient arterial supply due to the damaged or removed superior rectal artery (Shafik and Mostafa, 1996; Kreis et al., 2012).

While standard anatomical textbooks describe the superior and middle rectal arteries as a direct continuation of the inferior mesenteric artery and a branch of the internal iliac artery, respectively, the inconsistent presence and alternative anatomy of the middle rectal artery has been an area of question for far too long (DiDio et al., 1986; Patricio et al., 1988; Greenfield et al., 2001; Bilhim et al., 2013; Zhdanov et al., 2014; Standring et al., 2016; Kiyomatsu et al., 2017).

The role of the rectal arterial supply is considered to be essential for the operative management of recto-sigmoid cancer and haemorrhoidal disease (Bilhim et al., 2013). Hence, the function of the middle artery in the extensive rectal anastomosis may be especially significant for the provision of collateral blood flow during intestinal embolization (Iqbal et al., 2011; Zhdanov et al., 2014; Dalmia, 2015; Rutegard et al., 2016).

The intent of this study was thus two-fold, viz. to identify the arterial supply to the proximal rectum and to investigate the role of the middle rectal artery in the consequential vascularization.

MATERIALS AND METHODS

Subsequent to the ethical authorization by the relevant institutional body of the University of KwaZulu-Natal (BE 339/14) and in accordance with Chapter 8 of the National Health Act No. 61 of 2003, this study was conducted at the Department of Clinical Anatomy, School of Laboratory Medicine and Medical Sciences, University of KwaZulu-Natal, Durban, South Africa. It included the bilateral micro- and macro-dissection of ten fetal and ten adult cadaveric specimens (n = 40). The distribution of the sample size was represented by 9 females and 11 males. Race was not documented, as the fetal specimens could not be subjected to racial distinction.

For the purpose of this study, a few pertinent anatomical landmarks were employed. As the rectum is generally divided into proximal and distal parts, the proximal boundary was marked by the recto-sigmoid junction at vertebral level S3 where a coalescence of taeniae coli can be seen externally.

The distal boundary was marked by the anorectal junction at the level of the dentate line, just inferior to the tip of the coccyx. Since this study investigated the regional arterial supply to the proximal rectum, the three valves of Houston situated at the edges of the three lateral curves demarcated the proximal rectum into superior, middle and inferior thirds.

Morphologic observations detailing the proximal rectal arterial supply and the presence and/or variation of the middle rectal artery were recorded in

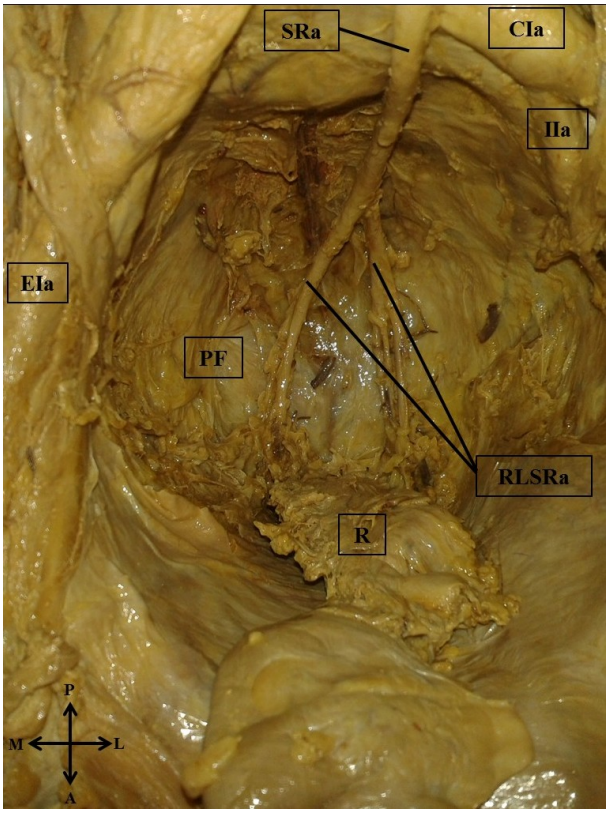

Fig 1. Inferior view of the pelvis showing the bifurcation of the superior rectal artery into right and left branches as it supplies the middle one-third of the proximal rectum. A: Anterior; Cia: Common iliac artery; EIa: External iliac artery; IIa: Internal iliac artery; L: Lateral; M: Medial; P: Posterior; PF: Pelvic floor; R: Rectum; RLSRa: Right and left branches of superior rectal artery; SRa: Superior rectal artery.

Table 1. Arterial supply to the regions of the proximal rectum. MRa: Middle rectal artery. MSa: Median sacral artery. SRa: Superior rectal artery.

Artery supplying proximal region of rectum		Side		Sex	
		Right	Left	Female	Male
Superior 1/3	**SRa**	30	27.5	10	47.5
***p* value**		0.749		0.000*	
Superior 2/3	**SRa**	17.5	15	32.5	0
	MRa	2.5	0	2.5	0
***p* value**		0.311		0.263	
Middle 1/3	**SRa**	10	15	2.5	22.5
	MRa	12.5	10	12.5	10
***p* value**		0.756		0.037*	
Inferior 2/3	**MRa**	7.5	12.5	20	0
***p* value**		0.429		0.000*	
Posterior middle 1/3	**MSa**	MSa does not arise bilaterally		20	40
***p* value**				0.199	
Postero-inferior 1/3	**MSa**	MSa does not arise bilaterally		5	0
***p* value**				0.257	

*Significant *p* value

accordance with the designated anatomical landmarks. The level of significance of laterality as well as sex was statistically determined using the Pearson Chi-Square and One-Way Anova Tests (SPSS version 21.0 - SPSS Inc., Chicago, Illinois, USA). A *p* value of <0.05 was considered to be statistically significant. In addition, the Binomial Test was employed to establish the statistical significance (if any) of deviations from the expected observations within the sample proportion. In this study, the null hypothesis for the Binomial Test was that the results did not differ greatly from what was expected.

RESULTS

Arterial supply of the proximal rectum

Laterality

The right sides of the superior one- and two-thirds of the proximal rectum appeared to have a greater arterial supply from the superior rectal and middle rectal arteries (Fig. 1, Table 1). Although the middle one-third of the proximal rectum was commonly supplied by the superior and middle rectal arteries on the left and right sides, respectively, the left side of the inferior two-thirds received the predominant arterial supply from the middle rectal artery (Table 1). The correlation of the arterial supply to the superior one-third, superior two-thirds, middle one-third and inferior two-thirds between right and left sides yielded *p* values of 0.749, 0.311, 0.756 and 0.429, respectively (Table 1).

Sex

In male individuals, the superior one-third and posterior middle one-third of the proximal rectum presented with an increased supply from the superior rectal and median sacral arteries, respectively (Fig. 2, Table 1). However, in female individuals the superior two-thirds, inferior one-third and postero-inferior one-third of the proximal rectum received a greater arterial supply from the superior and middle rectal and median sacral arteries (Table 1). Although the superior rectal artery principally supplied the middle one-third of the proximal rectum in male individuals, the middle rectal artery provided a reasonably frequent supply to this region in female individuals (Table 1). The comparison of sex with the arterial supply to the superior one-third, middle one-third and inferior two-thirds of the proximal rectum yielded statistically significant *p* values of 0.000, 0.037 and 0.000, respectively (Table 1). On the contrary, the correlation between sex and the arterial supply to the superior two-thirds, posterior middle one-third and postero-inferior one-third results in *p* values of 0.263, 0.199 and 0.257, respectively (Table 1).

Morphological nature of middle rectal artery

Laterality

While the normal origin of the middle rectal artery from the anterior division of the internal iliac artery occurred particularly on the left side, its absence was also predominant on the same side (Table 2). Interestingly, the presence of the middle rectal artery was accompanied by both the classical normal and variant origins (Table 2). The variation in the origin of the middle rectal artery was complemented by its origin directly from the inferior gluteal artery, an observation that only presented on the right side (Fig. 3, Table 2). In addition, the middle

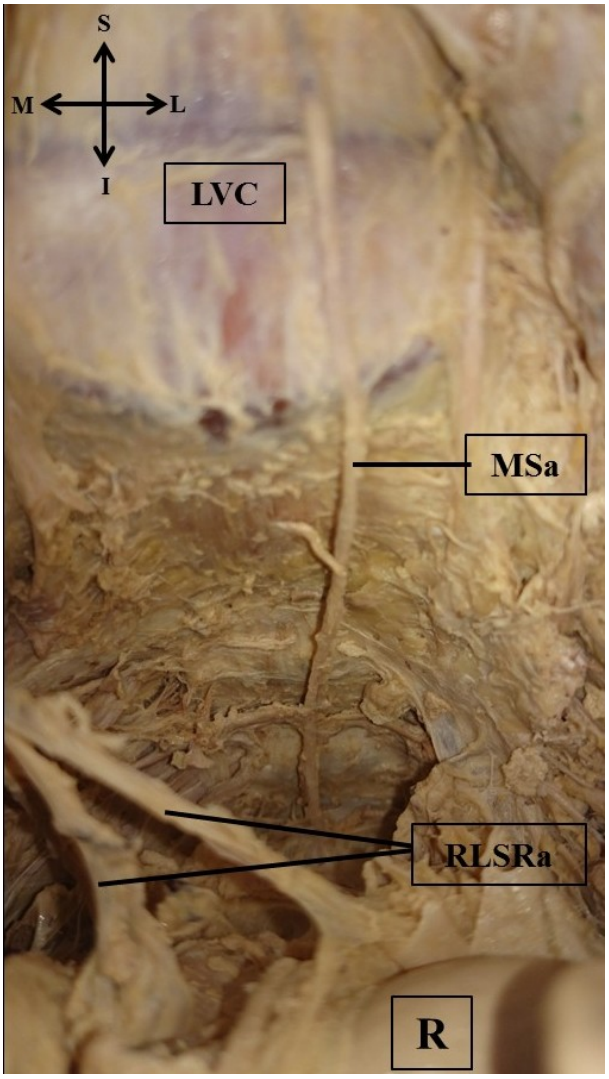

Fig 2. Antero-inferior view of the median sacral artery supplying the posterior middle one-third of the proximal rectum. I: Inferior; L: Lateral; LVC: Lumbar vertebral column; M: Medial; MSa: Median sacral artery; R: Rectum; RLSRa: Right and left branches of superior rectal artery; S: Superior.

rectal artery was seen to arise with the inferior vesical artery from a common trunk of the internal iliac arteries on both right and left sides equally (Fig. 4, Table 2). The comparison of laterality with the morphological nature of the middle rectal artery yielded a *p* value of 0.744 (Table 2).

Sex

The absence of the middle rectal artery in male individuals was a frequent observation (Table 2). In its presence, the middle rectal artery commonly reflected its normal anatomical origin in female individuals (Table 2). Although the direct origin of the middle rectal artery from the inferior gluteal artery was recorded in males only, it arose equivalently with the inferior vesical artery from a common trunk of the internal iliac arteries in both males and females (Table 2). A statistically significant *p* value of 0.002 was recorded for the correlation between sex and the nature of the middle rectal artery (Table 2).

DISCUSSION

Although previous studies have recorded the arterial supply to the rectum, no previous study has attempted to compare the significance of it with laterality and sex. In addition, the focus is generally centred on the rectum as a whole, as opposed to the proximal and/or distal segments specifically. The importance of this study, which is directed at the fractionized proximal rectal region, lies in the preservation of the respective arteries during the reversal of the Hartmann's Procedure (DiDio et al., 1986; Dalmia, 2015).

Arterial supply of the proximal rectum

Since the rectum is a richly vascularized organ, acute rectal ischemia, frank rectal gangrene and pseudoaneuryms of the respective rectal arteries are considered to be rare occurrences (Shafik and Mostafa, 1996; Iqbal et al., 2011; Zakeri and Cheah, 2012; Azimuddin and Raphaeli, 2013).

In this study, the predominant arterial supply to the proximal rectum was distinctly derived from the superior rectal artery. This greater prevalence in supply, arising principally from the superior rectal artery, has been reported in previous studies and indicates that the occlusion of the superior rectal artery and/or its parent artery may result in the anastomotic leakage of the rectum (Patricio et al.,

Table 2. Morphological nature of the middle rectal artery. IGa: Inferior gluteal artery. IIa: Internal iliac artery. Iva: Inferior vesical artery. MRa: Middle rectal artery.

Morphological Nature of MRa			Side		Sex	
			Right	Left	Female	Male
Absent			22.5	27.5	10	40
Present	**Normal Origin**	**Arose directly from IIa**	22.5	20	32.5	10
	Variation in Origin	**Arose directly from IGa**	2.5	0	0	2.5
		Arose with IVa from common	2.5	2.5	2.5	2.5
***p* value**			0.744		0.002*	

*Significant *p* value

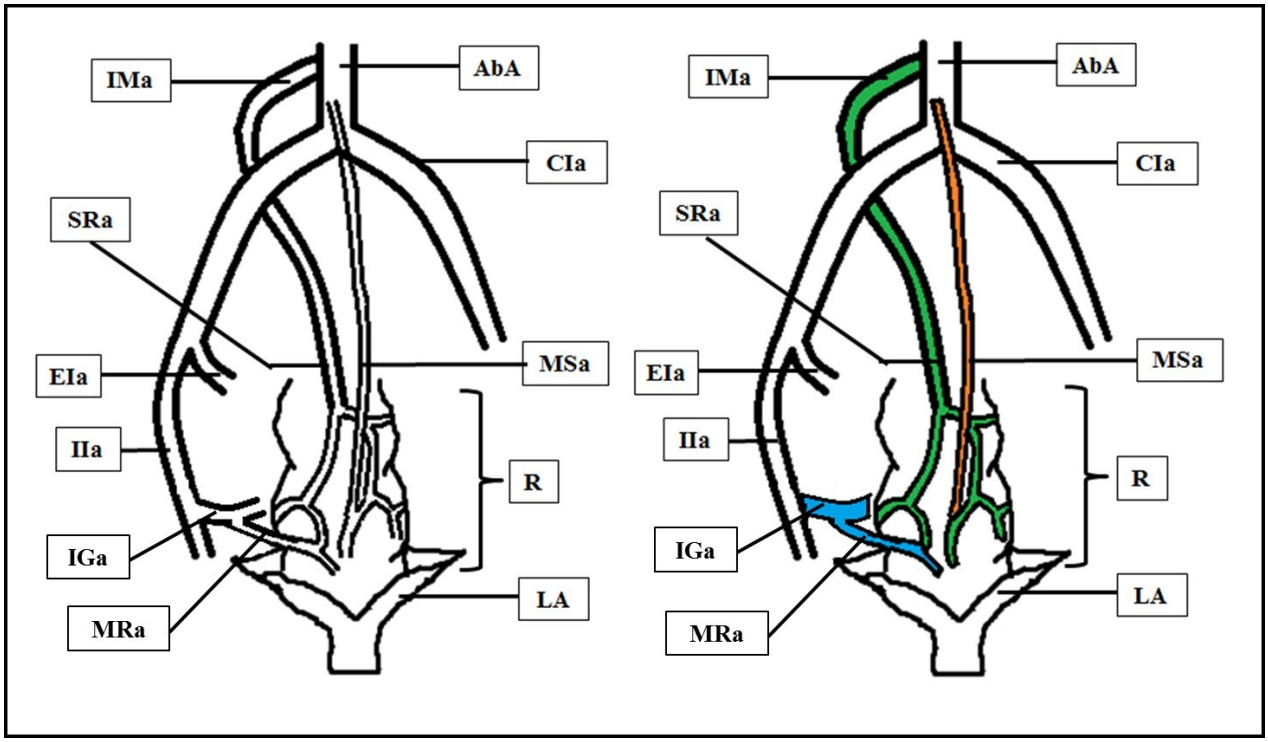

Fig 3. Schematic diagram of posterior view of middle rectal artery arising directly from the inferior gluteal artery. AbA: Abdominal aorta; Cia: Common iliac artery; EIa: External iliac artery; I: Inferior; IGa: Inferior gluteal artery; IIa: Internal iliac artery; Ima: Inferior mesenteric artery; L: Lateral; LA: Levator ani muscle; M: Medial; MRa: Middle rectal artery; MSa: Median sacral artery; R: Rectum; S: Superior; SRa: Superior rectal artery.

1988; Greenfield et al., 2001; Iqbal et al., 2011; Wakahara et al., 2015). Although a marginal arterial supply was observed from the middle rectal artery on both sides in males and females, the inconsistency of it as documented in the results of this study and in previous literature, may suggest that

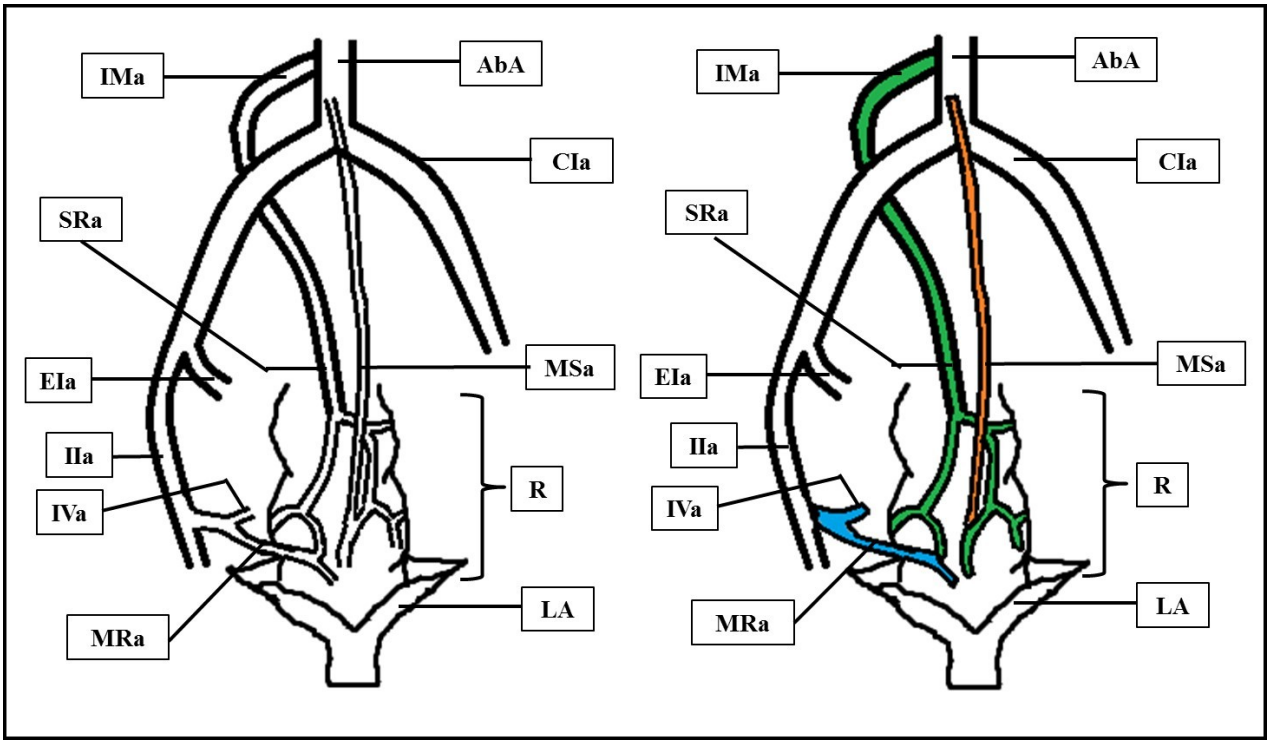

Fig 4. Schematic diagram of posterior view of inferior vesical and middle rectal arteries arising from a common trunk of the anterior division of the internal iliac artery. AbA: Abdominal aorta; Cia: Common iliac artery; EIa: External iliac artery; I: Inferior; IIa: Internal iliac artery; Iva: Inferior vesical artery; Ima: Inferior mesenteric artery; L: Lateral; LA: Levator ani muscle; M: Medial; MRa: Middle rectal artery; MSa: Median sacral artery; R: Rectum; S: Superior; SRa: Superior rectal artery.

the middle rectal artery is not the main arterial source of the rectum (Ayoub, 1978; DiDio et al., 1986; Greenfield et al., 2011; Bilhim et al., 2013; Zhdanov et al., 2014; Kiyomatsu et al., 2017). In the present study, the median sacral artery was found to supply the posterior aspects of the middle and inferior one-thirds of the proximal rectum, a finding that was also observed by Greenfield et al. (2001) and Standring et al. (2016).

There was no statistical significance established for the arterial supply to the superior one-third, superior two-thirds, middle one-third and inferior two-thirds of the rectum between right and left sides (Table 1). Despite the absence of a significant difference between sex and the arterial supply to the superior two-thirds, posterior middle one-third and postero-inferior one-third of the rectum, it may be postulated, from the statistically significant *p* values recorded for the comparison of sex with the arterial supply to the respective proximal rectal regions, that the superior and middle rectal arteries are the primary vascular sources to the superior one-third in males and the inferior two-thirds in females, respectively (Table 1). Since the middle one-third of the proximal rectum received a dual supply that presented with a statistical significance when compared with sex, the superior and middle rectal arteries appear to be the main arterial sources to this region in males and females, respectively (Table 1).

Morphological nature of middle rectal artery

In the present study, the prevalence of the middle rectal artery was similar to that recorded in previous studies, thus highlighting the inconsistent morphological nature of this artery (Ayoub, 1978; DiDio et al., 1986; Bilhim et al., 2013; Zhdanov et al., 2014; Kiyomatsu et al., 2017). In addition to its classical origin from the anterior division of the internal iliac artery, the middle rectal artery also arose directly from the inferior gluteal artery, as well as with the inferior vesical artery from a common trunk of the anterior division of the internal iliac artery, the latter of which is a unique finding as it has not been reported in the literature reviewed. However, the origin of the middle rectal artery as a direct branch from the inferior gluteal artery was previously recorded by DiDio et al. (1986) and Bilhim et al. (2013).

Laterality

The results of this study revealed that the presence of the middle rectal artery is more common bilaterally than unilaterally. Although this finding corroborated that of DiDio et al. (1986), it differed from that reported by Bilhim et al. (2013). Zhdanov et al. (2014) found that the middle rectal artery was prominently absent on the right side. However, the present study documented a marginally comparable absence of this artery on both right and left sides (Table 2). Furthermore, no level of statistical significance (*p* value = 0.744) was observed for the comparison of laterality with the morphological nature of the middle rectal artery (Table 2).

Sex

According to Skandalakis et al. (2004), the absence of the middle rectal artery in female individuals may be considered a regular occurrence as it may be substituted by the uterine artery. On the contrary, this study noted the absence of the middle rectal artery to be higher in male individuals. The statistically significant *p* value of 0.002 that was recorded for the correlation between sex and the nature of the middle rectal artery may indicate the greater prevalence of the artery in female individuals, irrespective of the normal and/or variant origins (Table 2).

Given that the sample size was relatively small, the Binomial Test was employed to evaluate the distribution of the population within the sample. The null hypotheses were retained for the categories defined by sex, laterality and the superior one-third of the rectum, as the observed and expected results were similar. However, the null hypotheses were rejected for the categories defined by the superior two-thirds, middle one-third, inferior two-thirds, posterior middle one-third and the postero-inferior one-third of the rectum, as the observed results differed significantly from the expected results. As a result, it is recommended that future study is accompanied by a power analysis and includes a larger sample size that is representative of the population proportion.

Conclusion

The proximal rectum was supplied primarily by the superior rectal artery. In addition, the findings of this study emphasize the inconsistent morphological nature of the middle rectal artery, thus confirming that it is not a principal arterial source to the proximal rectum. Since this study investigated the regional arterial supply to the proximal rectum in accordance with appropriate anatomical landmarks, it may prove to be of surgical relevance as it would assist to preserve the arterial supply during the Hartmann's Procedure. Furthermore, the specific arterial supply to the proximal rectum may act as landmark indicators of the fractionized region/s in question, thus using the vascular distribution to demarcate the proximal rectum.

REFERENCES

AYOUB SF (1978) Arterial supply to the human rectum. *Acta Anat (Basel)*, 100 (3): 317-327.

AZMUDDIN K, RAPHAELI T (2013) Acute ischaemic gangrene of the rectum: Report of 3 cases and review of literature. *Int J Surg Case Reports*, 4: 1120-1123.

BARBIEUX J, PLUMEREAU F, HAMY A (2016) Current indications for the Hartmann procedure. *J Visc Surg*, 153 (1): 31-38.

BILHIM T, PEREIRA JA, TINTO HR, FERNANDES L, DUARTE M, O'NEILL JE, PISCO JM (2013) Middle

rectal artery: myth or reality? Retrospectve study with CT angiography and digital subtraction angiography. *Surg Radiol Anat,* 35: 517-522.

DALMIA S (2015) Hartmann's Procedure and its Outcome – An Analysis of 78 Consecutive Cases. *IAM*, 8 (59): 1-5.

DIDIO L, DIAZ-FRANCO C, SCHEMAINDA R, BEZERRA AJC (1986) Morphology of the middle rectal arteries. *Surg Radiol Anat*, 8 (4): 229-236.

GREENFIELD LJ, MULHOLLAND MW, OLDHAM KT, ZELENOCK GB, LILLEMOE KD (2001) *Surgery: Scientific Principles and Practice*. Lippincott Williams and Wilkins.

IQBAL J, KAMA L, PARKASH M (2011) Traumatic pseudoaneurysm of superior rectal artery- an unusual cause of massive lower gastrointestinal bleed: A case report. *Gastroenterol Res Pract,* 4 (1): 36-38.

KIYOMATSU T, ISHIHARA S, MURONO K, OTANI K, YASUDA K, NISHIKAWA T, TANAKA T, HATA K, KAWAI K, NOZAWA H, YAMAGUCHI H, WATANABE T (2017) Anatomy of the middle rectal artery: a review of the historical literature. *Surg Today*, 47 (1): 14-19.

KREIS ME, MUELLER MH, THASLER WH (2012) Hartmann's procedure or primary anastomosis? *Dig Dis*, 30 (1): 83-85.

MURONO K, KAWAI K, KAZAMA S, ISHIHARA S, YAMAGUCHI H, SUNAMI E, KITAYAMA J, WATANABE T (2015) Anatomy of the inferior mesenteric artery evaluated using 3-dimensional CT angiography. *Dis Colon Rectum*, 58 (2): 214-219.

PATRICIO J, BERNADES A, NUNO D, FALCAO F, SILVEIRA L (1986) Surgical anatomy of the arterial blood-supply of the human rectum. *Surg Radiol Anat,* 10 (1): 71-75.

RUTEGARD M, HASSMEN N, HEMMINGSSON O, HAAPAMAKI MM, MATTHIESSEN P, RUTEGARD J (2016) Anterior resection for rectal cancer and visceral blood flow: an explorative study. *Scand J Surg,* 105 (2): 78-83.

SHAFIK A, MOSTAFA H (1996) Study of the arterial pattern of the rectum and its clinical application. *Acta Anat (Basel),* 157 (1): 80-86.

SKANDALAKIS JE (2004) *Skandalakis' Surgical Anatomy: The Embryology and Anatomic Basis of Modern Surgery*. Paschalidis Medical Publication Ltd, USA.

STANDRING S (2016) *Gray's Anatomy: The Anatomical Basis of Clinical Practice*. Elsevier Ltd, Spain.

WAKAHARA T, TOYOKAWA A, ASHITANI H, TSUCHIDA S, HASEGAWA Y (2015) Comparison of laparoscopic sigmoidectomy with and without preservation of the superior rectal artery: A single-instituition retrospective study. *Asian J Endoscopic Surg*, 8 (1): 29-33.

ZAKERI N, CHEAH SO (2012) A case of massive lower gastrointestinal bleeding: superior rectal artery pseudoaneurysm. *Annals Acad Med,* 41 (11): 529-531.

ZHDANOV AI, KAZAREZOV OV, OLSHANSKIY MS, KOROTKIKH NN (2014) Role of middle rectal artery in rectum bloods supply. *Medical Sciences,* 10: 70-74.