


CASE REPORT

Open Access



Right paraduodenal hernia, classification, and selection of surgical methods: a case report and review of the literature

Xiao-Long Wang^{1,4} , Gui-Xiu Jin², Jian-Feng Xu¹, Zhi-Rong Chen¹, Li-Meng Wu³ and Zhi-Long Jiang^{1*}

Abstract

Background Considering that right paraduodenal hernia is a rare internal hernia with abnormal anatomy and is often encountered during an emergency, surgeons may lack knowledge about it and choose incorrect treatment. Thus, this case report is a helpful complement to the few previously reported cases of right paraduodenal hernia. Additionally, we reviewed all the reported right paraduodenal hernia cases and proposed appropriate surgical strategies according to different anatomical features.

Case presentation The case involved a 33-year-old Chinese male patient who was admitted to the hospital due to abdominal pain. The patient was initially diagnosed with small bowel obstruction, and conservative treatment failed. An emergency operation was arranged, during which a diagnosis of right paraduodenal hernia was made instead. After surgery, the patient recovered well without abdominal pain for 2 years.

Conclusion Although right paraduodenal hernia accounts only for a small proportion of paraduodenal hernia, its anatomical characteristics can vary considerably. We divided right paraduodenal hernia into three types, with each type requiring a different surgical strategy.

Keywords Right paraduodenal hernia, Internal hernia, Surgical methods, Mesocolic hernia

Introduction

Paraduodenal hernias (PDHs) are congenital internal hernias. The incidence of PDH is unclear because some patients remain asymptomatic throughout their lives. According to autopsy results, the incidence of internal hernias is between 0.2% and 0.9%, while PDH accounts

for approximately 53% of internal hernias [1–5]. The low incidence of PDH has also been demonstrated in autopsies [6–8]. PDH can be divided into left and right PDH according to completely different embryological and anatomical features [9, 10]. Right PDH is less common than left PDH, with a 1:3 ratio [1, 2, 11–15].

In clinical practice, a considerable number of patients with right PDH do not receive an accurate diagnosis preoperatively because right PDH is rare and most commonly presents as an emergency [5]. During surgery, appropriate surgical methods could not be adopted timely due to unfamiliarity with the anatomy of right PDH, resulting in prolonged operation and poor recovery of the patient. In 2021, we encountered a case of right PDH that was diagnosed intraoperatively. After the operation, we researched the literature and found that there was no article summarizing right PDH based

*Correspondence:

Zhi-Long Jiang
txjzl@163.com

¹ Department of General Surgery, Taixing People's Hospital, No. 1, Changzheng Road, Taixing, Jiangsu, China

² Department of Gynecology and Obstetrics, Taixing People's Hospital, Taixing, Jiangsu, China

³ Department of Radiology, Taixing People's Hospital, Taixing, Jiangsu, China

⁴ Department of General Surgery, The First Affiliated Hospital of Soochow University, Suzhou, Jiangsu, China



© The Author(s) 2023. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated in a credit line to the data.

on anatomic features. Additionally, in many reports, the Ladd's procedure was used without choosing an appropriate surgical method on the basis of the anatomy of right PDH. Therefore, we aimed to classify right PDH according to its anatomical and etiological features. According to this classification, different types of surgery can be selected.

Materials and methods

We found nearly 500 literature reports on PDH using the keywords "paraduodenal hernia," "para-duodenal hernia," "Treitz's hernia," and "mesocolic hernia" in PubMed. After an initial analysis of the literature, only articles with right PDH confirmed by surgery and with imaging or anatomical illustrations from the literature explaining anatomical features were included in our study. We excluded cases in which right PDH was not surgically confirmed and anatomical features could not be identified as well as studies in languages other than English and published before 1970. Furthermore, three studies were excluded due to missing full text. Along with the cases reported in the literature, right PDH encountered in our hospital was also included and presented as a case report.

All cases included an obtained informed consent signed by patients. The research protocol complied with the ethical standards of the Institutional Research Committee and the 1964 Declaration of Helsinki and its subsequent amendments. As this is a retrospective observational study and review of the literature, no formal consent to this study was required, nor approval by the Institutional Research Committee.

Case report

A 33-year-old Chinese male patient presented to our emergency department with 4 hours of acute abdominal pain. The patient reported no nausea, vomiting, or other associated symptoms. He had no medical history of abdominal discomfort or abdominal surgery. Physical examination revealed tenderness in the right lower quadrant with rebound tenderness and active bowel sounds. In the emergency department, computed tomography (CT) was performed. The interim report indicated that a clumpy, "C"-shaped abnormal intestinal shadow was observed in the right mid-upper abdomen, with increased and entangled mesenteric density in the surrounding adipose space, suggesting the possibility of internal abdominal hernia (Fig. 1).

After admission, the patient received conservative treatment for 4 hours, but no relief of abdominal pain was observed. After consulting his family members, an emergency operation was agreed upon. Laparoscopy was first used to assess the entire abdomen. We found that the third segment of the duodenum, jejunum, and

most of the ileum were located in a clear capsule (Fig. 2). The cecum was located in the right lower quadrant, and 25 cm from the ileocecum, a segment of the small bowel of about 5 cm was compressed beneath the superior mesenteric vessels. We then decided to switch to open surgery. We cut the unvascularized area (the jejunocolic isthmus) (Fig. 3B) on the dorsal side of the superior mesenteric vessels (Fig. 4B), cephalic to the root of the superior mesenteric vessels. The orifice of the hernia sac was fully opened. During the operation, the anterior wall of the hernia sac (ascending mesocolon) was opened by mistake and then completely repaired with absorbable sutures. The patient's postoperative course was uneventful. After 2 years of follow-up, the patient reported no abdominal discomfort.

Results of literature review

We identified a total of 500 records from the database. First, we performed a rough screening by reading abstracts to exclude patients with left PDH. Then, we read the full text carefully, excluding cases with a history of previous abdominal surgery, other abdominal diseases, and unclear descriptions, finally including 34 cases. The ratio of male to female patients was about 21:12. The median age was about 29 years. The number of patients with disease presenting after the age of 50 years was extremely small. The emergency surgery rate was approximately 60%. Afterward, we categorized all cases. The classification is based on anatomical characteristics combined with the theory of embryonic development, as detailed in the Discussion section. Table 1 demonstrates that surgical options for each type of right PDH are different. Classifying cases can allow clinicians to become familiar with this disease and choose a reasonable surgical method.

Discussion

At present, it is generally accepted that PDH is related to changes in peritoneal fixation and vascular folds. Most literature ascribes the pathogenesis of right PDH to the malrotation of the prearterial limb of the midgut loop [5, 6, 9, 10, 12, 24, 28, 45–47], which is an incomplete speculation. Since right PDH is a rare disease, and most reports are case reports only, it is difficult to have a comprehensive understanding of right PDH. Combining cases encountered in clinical practice and cases mentioned in previous reports, here we classified right PDH into three types according to anatomical and etiological features and then summarized surgical methods for the treatment of right PDH.

Right PDH is a part of or the entire small intestine entrapped in Waldeyer's fossa due to congenital factors. It is located laterally and inferiorly to the descending

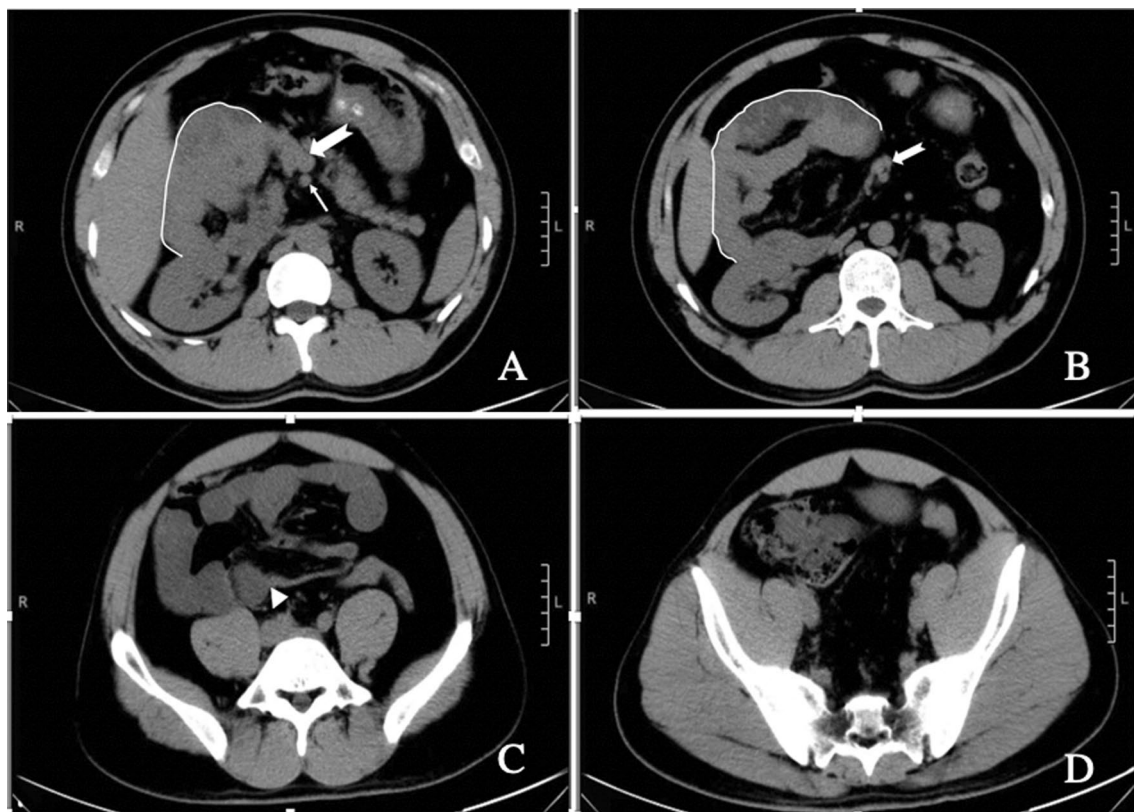


Fig. 1 White line: hernia sac. Long arrow: superior mesenteric artery. Dovetail arrow: superior mesenteric vein and its branches. Triangle: the obstruction site. **A** Superior mesenteric vein (SMV) and superior mesenteric artery (SMA) arranged anteroposteriorly; there was no horizontal part of the duodenum on the dorsal side of the superior mesenteric vessels. **B** Jejunal vessels originate from the left side of the SMV and then turn to the right side of the abdomen. **C** White arrow indicates the obstruction site. **D** There was a paucity of small bowel loops in the pelvis. The cecum was located in the right lower quadrant

part of the duodenum. The mesentery of the ascending colon forms the anterior wall, within which lie ileocolic and right colic vessels. The posterior wall is formed by the posterior parietal peritoneum. The inner and lateral boundaries are the superior mesenteric vessels and lateral attachments of the right colon. There are additional anatomical characteristics of right PDH that can vary significantly. Moreover, some authors use certain anatomical features as diagnostic criteria for right PDH. For example, the afferent and efferent intestinal loops of right PDH in the hernia opening are reported as tight and narrow [1, 3, 15, 48]. In other reports, features such as the third part of the duodenum not crossing the midline and the cecum remaining in the lower right quadrant are used as some criteria for the diagnosis of right PDH [14, 15, 33]. However, these anatomical features correspond to only a subset of right PDHs.

According to different anatomical features, we divided right PDH into three types. The first type of right PDH (Fig. 3A) has an intact duodenal morphology; hence, the duodenum has normal horizontal and

ascending parts, and the ligament of Treitz is in its normal anatomical position [1–3, 6, 12, 13, 15, 18, 19, 22, 28, 34, 36–39, 42]. The orifice of the hernia sac is located in the jejuno-cecolic isthmus, dorsally to the superior mesenteric vessels. The hernia contents mainly include the small intestine. Both afferent and efferent loops pass through the hernia orifice. From an etiological standpoint, there is no evidence of midgut malrotation in this type of right PDH. The main pathogenesis of the first type of right PDH might be an inadequate fusion of ascending mesocolon and retroperitoneum, resulting in the formation of Waldeyer's fossa. This fits Moynihan's theory [49] and is supported by other literature [13, 50]. Depending on the location and size of the opening of the hernia sac and the amount of hernia contents, hernia contents might return to their normal position by themselves after postural changes or treatment in some patients. Clinically, these patients have recurrent abdominal pain lasting for several years but no obvious abnormalities on CT or gastrointestinal angiography.

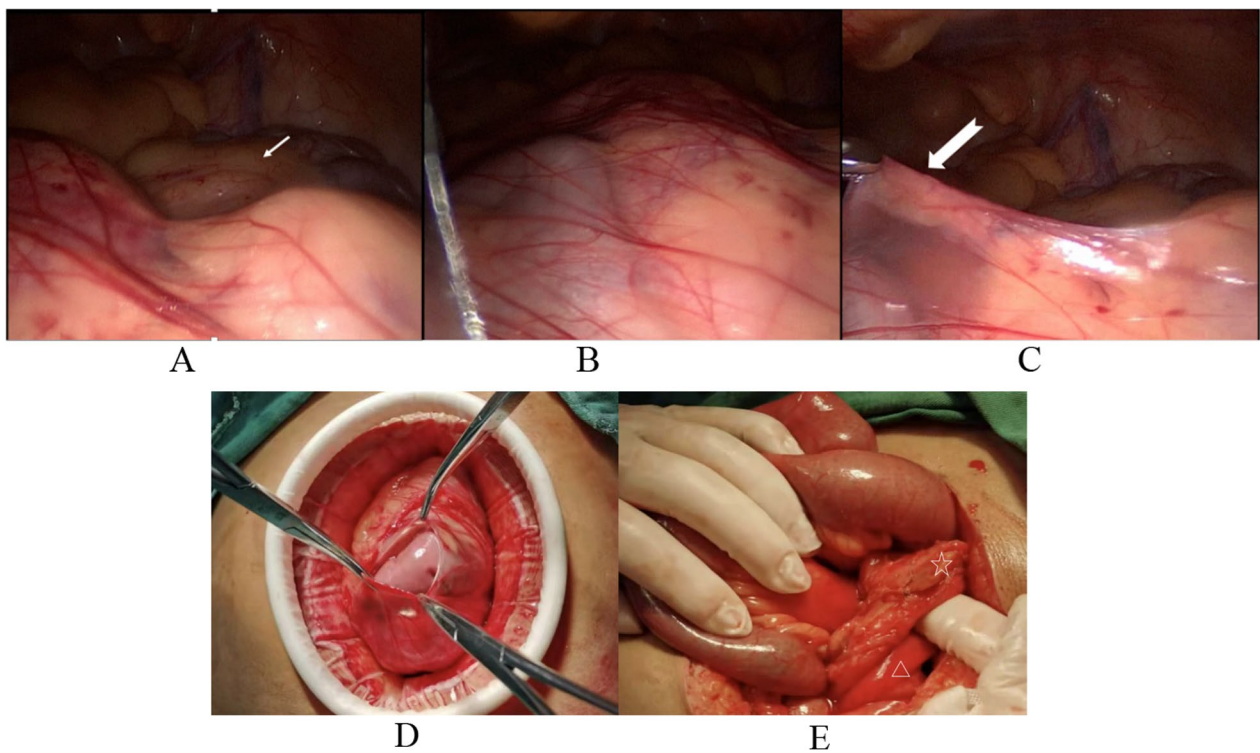


Fig. 2 Long arrow: the cecum. Dovetail arrow: the hernia sac. Triangle: the efferent loop. Star: superior mesenteric vessels and surrounding tissues. **A** The cecum in its normal position. **B** and **C** The original appearance of the hernia sac and the appearance after it was lifted. **D** and **E** The hernia sac (ascending mesocolon) was opened by mistake

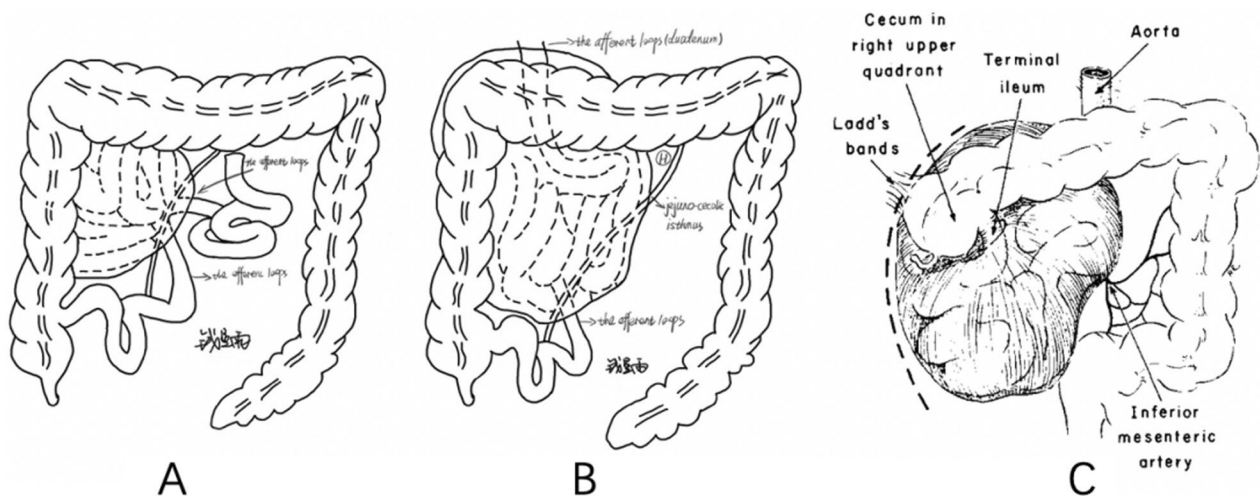


Fig. 3 **A** The first type of right paraduodenal hernia. **B** The second type of right paraduodenal hernia. **C** The third type of right paraduodenal hernia [45] (reprinted by permission from Copyright Clearance Center provided by Elsevier: *The American Journal of Surgery*, 1974. 128(3): p. 358–361)

According to previously reported cases and the case reported in this article, the common anatomic features of the second type of right PDH are the passage of only the efferent loop through the hernia orifice and the absence of the ligament of Treitz [14, 16, 20, 21, 23–25, 27, 29, 32,

33, 35, 40, 41, 43, 44] (Fig. 3B). Absence of the ligament of Treitz means that the Treitz’s angle is located to the right of the mesenteric vessels. On imaging, the horizontal portion of the duodenum is short and not evident in some patients (Fig. 1B). In others, the horizontal portion

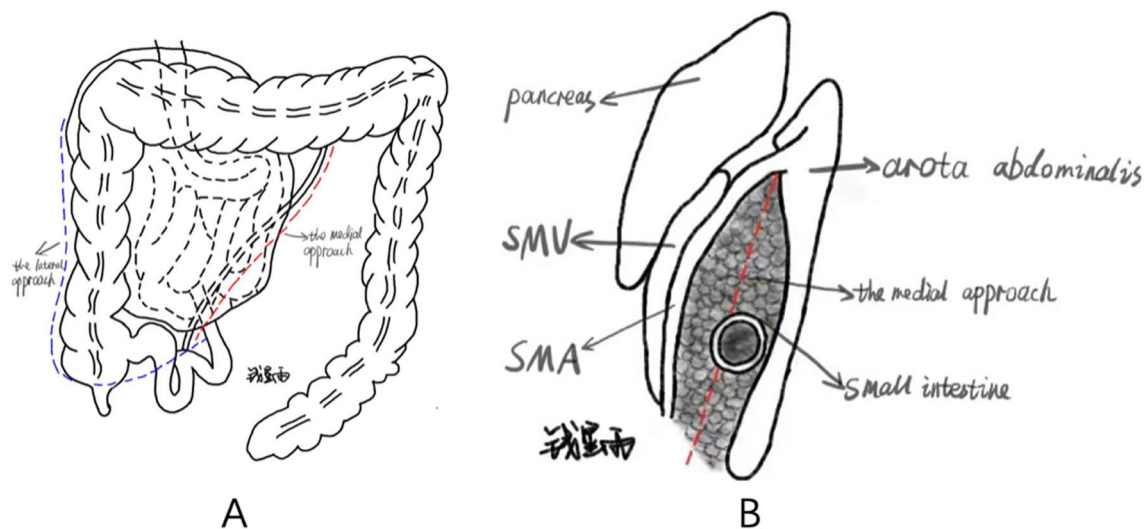


Fig. 4 **A** The blue dashed line indicates the lateral approach; the red dashed line indicates the medial approach. **B** Left view of the medial approach

of the duodenum runs close to the mesenteric vessel but does not pass behind the root of the mesenteric vessels. The horizontal part of the duodenum passes directly into the hernia sac. The pathogenesis of this kind of right PDH is consistent with the hypothesis proposed by Andrews in 1923 [51]. In his opinion, right PDH is the result of poor or incomplete rotation of the prearterial limb of the midgut loop [51]. The rotation of the posterior arterial limb is normal, which is consistent with the normally located cecum. In this type of right PDH, it is necessary to pay attention to the change of the orifice position of the hernia sac. Different positions require different treatment methods.

The typical anatomical features of the third type of right PDH are based on the second type of right PDH. Specifically, the Ladd's bundle extends from the abnormal site of the cecum to the peritoneum or liver, fixing the cecum in an abnormal position, usually in the right upper quadrant (Fig. 3C) [17, 26, 30, 31]. During this process, the Ladd's ligament crosses and compresses the duodenum or small intestine, causing intestinal obstruction. There is usually an adhesion between the mesenteric membrane of the jejunal loop and the mesenteric membrane of the ileal loop (mesenteric fusion of Pellerin). In this case, the rotation of pre- and postarterial segments is incomplete, which is a view different from Andrews' theory [51] and supported by other literature [30].

Different anatomic features and etiologies may require different surgical methods. It is unrealistic to pursue the same surgical procedures in all types of right PDH. In the selection of surgical methods to treat PDH, a surgeon should follow the general principles of surgical treatment of abdominal hernia and then choose different surgical

methods according to different anatomical characteristics. The surgical treatment of internal hernia is based on the principle of hernia reduction, repair of the defect, or enlargement of the hernia opening [49]. Specifically for right PDH, the appropriate surgical method should be selected according to its anatomical characteristics.

In the first type of right PDH, the rotation of pre- and postarterial segments is normal, and the main cause of this disease is the fusion defect of the ascending mesocolon with the posterior peritoneal wall. For type I right PDH, in Table 1, closing the orifice was chosen in five cases [18, 34, 36, 39, 42], and enlarging the orifice was chosen in five cases. The surgical plan for expanding the hernia orifice included the Ladd's procedure(s) (the lateral approach [Fig. 4A]) in three cases [6, 12, 28] and opening the avascular area dorsal to the superior mesenteric vessels in one case [19], similar to the plan shown in Fig. 4B. Another case involved the incision of the lower peritoneal reflection of the hernia orifice below and parallel to the superior mesenteric vessels [38]. Surgical methods used were unknown in four cases. On the basis of the theory of defective fusion of retroperitoneal tissue with the ascending mesocolon, closure of the hernia sac opening should be preferred to avoid re-herniation of the small bowel, as is done in left PDH. This method will not create a new separation surface in the abdominal cavity, reducing the possibility of postoperative adhesions. Furthermore, this surgical approach is supported by the literature [13, 39]. However, in patients with severe infection and severe edema of peritoneal and posterior peritoneal tissue, suturing might not be an appropriate approach due to possible suture incompleteness, in which tissue tears

Table 1 Published cases of surgically confirmed right PDHs

| No. | Author | Time | Patient | Emergency ^a | Surgery | Type | SO ^b |
|-----|--|------|---------|------------------------|----------------------------------|------|-----------------|
| 1 | Tadaomi Fukada <i>et al.</i> [16] | 2010 | 46/M | Y | Close the orifice | 2(H) | Y |
| 2 | Marisa E. Schwab <i>et al.</i> [17] | 2022 | 84/M | Y | Ladd's procedure | 3 | |
| 3 | Mohammed Hassan <i>et al.</i> [18] | 2012 | 19/M | Y | Close the orifice | 1 | |
| 4 | Bao-Lin Liu <i>et al.</i> [19] | 2010 | 43/M | Y | The medial approach ^c | 1 | |
| 5 | N. Peru <i>et al.</i> [20] | 2020 | 29/M | Y | Ladd's procedure(s) ^d | 2 | |
| 6 | Michelle Ong [21] | 2017 | 53/F | Y | Widen hernia orifice | 2 | |
| 7 | L.J. Yeoman <i>et al.</i> [22] | 1994 | 27/M | Y | Unclear | 1 | |
| 8 | David M. Warshauer <i>et al.</i> [23] | 1992 | 32/M | Y | Unclear | 2 | |
| 9 | Enrico Erdas <i>et al.</i> [24] | 2014 | 32/F | Y | Close the orifice | 2(H) | |
| 10 | Venkatraman Indiran <i>et al.</i> [25] | 2016 | 19/M | Y | Ladd's procedure(s) | 2 | |
| 11 | Rahul, K. <i>et al.</i> [26] | 2013 | 11/M | N | Ladd's procedure | 3 | |
| 12 | E. Antedomenico <i>et al.</i> [27] | 2004 | 24/F | N | Ladd's procedure(s) | 2 | |
| 13 | John Mathew Manipadam <i>et al.</i> [28] | 2018 | 31/F | N | Ladd's procedure(s) | 1 | |
| 14 | James G. Bittner IV [6] | 2009 | 26/F | unclear | Ladd's procedure(s) | 1 | |
| 15 | Stephanie Walkner <i>et al.</i> [29] | 2019 | 37/M | N | Ladd's procedure(s) | 2 | |
| 16 | S. Rajesh <i>et al.</i> [30] | 2015 | Unclear | Unclear | Ladd's procedure | 3 | |
| 17 | Ramnik V. Patel <i>et al.</i> [31] | 2013 | 1W/M | Y | Ladd's procedure | 3 | |
| 18 | Kapil Rampal <i>et al.</i> [32] | 2022 | 26/M | Y | Ladd's procedure(s) | 2 | |
| 19 | H.Y. Yoo <i>et al.</i> [33] | 2000 | 19/F | Unclear | Close the orifice | 2(H) | |
| 20 | Thomas B. Coopwood <i>et al.</i> [34] | 1972 | 42/F | Unclear | Close the orifice | 1 | |
| 21 | Chien-Heng Lin <i>et al.</i> [14] | 2008 | 15/M | Unclear | Unclear | 2 | |
| 22 | Viktoria Lamprou <i>et al.</i> [35] | 2022 | 37/F | Y | Close the orifice | 2(H) | |
| 23 | Takahiro Tomino <i>et al.</i> [36] | 2015 | 23/M | Y | Close the orifice | 1 | |
| 24 | Vijay Anand Ismavel <i>et al.</i> [37] | 2021 | 23/M | Y | Unclear | 1 | |
| 25 | Andrew S. Olearchy <i>et al.</i> [38] | 1979 | 27/M | Y | Widen the orifice | 1 | |
| 26 | Yen-Hsiu Liao <i>et al.</i> [39] | 2011 | 45/F | Y | Close the orifice | 1 | |
| 27 | Navin Poudel <i>et al.</i> [40] | 2021 | 36/M | N | Ladd's procedure(s) | 2 | |
| 28 | Asif Abdullah <i>et al.</i> [41] | 2010 | 48/F | Y | Ladd's procedure(s) | 2 | |
| 29 | Basilios Papaziogas <i>et al.</i> [42] | 2004 | 17/M | Y | Close the orifice | 1 | |
| 30 | T.K.Y. Lee <i>et al.</i> [43] | 1990 | 29/M | N | Widen the orifice | 2 | |
| 31 | Tsuyoshi Shinohara <i>et al.</i> [12] | 2004 | 12/M | Y | Ladd's procedure(s) | 1 | |
| 32 | M. A. Meyers [15] | 1970 | 50/F | Unclear | Unclear | 1 | |
| 33 | Takeyama, N. <i>et al.</i> [1] | 2005 | 31/M | Y | Unclear | 1 | |
| 34 | Kwan, B. [44] | 2020 | 18/F | Unclear | Close the orifice | 2(H) | |

^a Emergency indicates emergency surgery

^b SO indicates secondary surgery

^c The medial approach indicates the approach described in Fig. 4

^d Ladd's procedure(s) is described as the separation of the ascending colon and the cecum along the white line of Toldt, with the medial side ensuring that the hernia sac opening is reached. It is not the standard Ladd's procedure, but it was expressed as Ladd's procedure in many reports. This paper uses the lateral approach, as shown in Fig. 4, which is a way to enlarge the orifice of the hernia sac. The lateral approach is used in place of the Ladd's procedure(s) in the following section

where the sutures were placed might cause a secondary hernia of the small intestine and injury to the superior mesenteric vessels. Thus, dilation of the hernial sac is a reasonable option in this setting. According to Table 1, there are currently three scenarios for enlarging the orifice. Among them, the lateral approach was used in three cases [6, 12, 28] without serious complications reported in the literature. However, in the

literature using this protocol, the cause of type I right PDH is attributed to intestinal malrotation. Additionally, this surgical method completely destroys the normal anatomy in the abdominal cavity and completely frees the ascending colon and cecum. Finally, there are certain disadvantages, such as a large separation surface. The protocol adopted in our case (Fig. 4B) does not have this disadvantage and can achieve the purpose

of surgery while reducing trauma and maintaining the original anatomy in the abdominal cavity.

For type II right PDH, the main etiological features are the absence of the ligament of Treitz, the presence of only the efferent intestinal loops in the hernia orifice, and normal rotation of the postarterial limb of the midgut loop. We suggest that the ideal approach for type II right PDH is to fully dilate the hernia orifice. The choice of surgical regimen for type II right PDH presented in Table 1 can lead to the same conclusion. There are two ways to expand the hernia sac opening: the medial approach and the lateral approach (Fig. 4A). The case reported here included a complete opening of the avascular area dorsal to the superior mesenteric vessels (Fig. 4B). The case reported by Lee *et al.* used a similar surgical approach [43]. The lateral approach is described in several articles [20, 25, 27, 29, 32, 40, 41], and similar to the above-mentioned method, divides the lateral peritoneal folds of the right colon and then dilates the hernia orifice. Considering the obtained results, this surgical method can indeed achieve the purpose of surgery. In a special case of this type, the hernia orifice opens at the root of the superior mesenteric vessel (Position H, Fig. 3B) [16, 24, 33, 35, 44]. Some authors reduce the contents of the hernia and narrow the orifice of the hernia sac up to the point that the proximal jejunum can just pass through [24, 33, 35, 44]. This operative approach has two drawbacks. First, due to the absence of Treitz's ligament, this type of right PDH lacks binding force to the proximal jejunum, which might re-herniate into the hernia sac; therefore, some authors use an absorbable mesh to immobilize the proximal jejunum [44]. Second, there is also a report of secondary operations due to superior mesenteric artery (SMA) compression syndrome [16]. The intestinal clusters that pass through the hernia orifice into the sac seem to lift up the SMA into the ventral position, which masks the true angle of the SMA relative to the abdominal aorta [16]. Therefore, considering that PDH is mostly performed in an emergency, it is difficult to assess the true angle of the SMA relative to the abdominal aorta before and during surgery in this particular type of right PDH. Furthermore, the obstruction is located in the efferent loop. Thus, the medial approach (Fig. 4B) might be more appropriate.

For type III PDH, the Ladd's procedure is a standard protocol. First, the Ladd's bands are cut off, and the ascending colon is freed from the greater omentum and the greater curvature of the stomach, allowing the ileocecal junction to be placed on the left lower quadrant. The Treitz's angle is then loosened to avoid twist and angulation of the duodenum. Afterward, any adhesions between the mesentery of the first jejunal loop and that of the last ileal loop (mesenteric fusion of Pellerin) are removed [52, 53]. Finally, the jejunum is located in the upper right

abdomen, and the ileocecal junction is located in the lower left abdomen.

The classification of right PDH can also be described from the perspective of embryonic development. The final location of the gut is related to two factors. First, the duodenum grows longitudinally during development, pushing the duodenojejunal junction dorsally to the superior mesenteric vessels and eventually to the left side of the vertebral column [54]. This process is essential for the proper alignment of the gut within the abdominal cavity. In multiple literatures [17, 20, 23, 25, 30, 35, 40] as well as the case reported in this study, the relative positions of the duodenojejunal junction, SMV, and SMA further substantiate this process. The SMA appears to revolve around the SMV on the basis of the location of the duodenojejunal junction (Fig. 5). Second, the small intestine develops rapidly within the umbilical cord and then pushes the cecum to a different location [54]. This suggests that the final position of the cecum is actually a passive result. Thus, the above-described findings provide a basis for the classification of right PDH from the perspective of embryonic development. The first type of right PDH is associated with problems with the fusion of the ascending mesocolon and the dorsal peritoneum, while the second type occurs due to failure to push the duodenojejunal junction into its normal position during early duodenal development. The third type superimposes the abnormality of the position of the cecum on the basis of the second type.

From the above-presented observations of embryonic development, we can further discuss the surgical

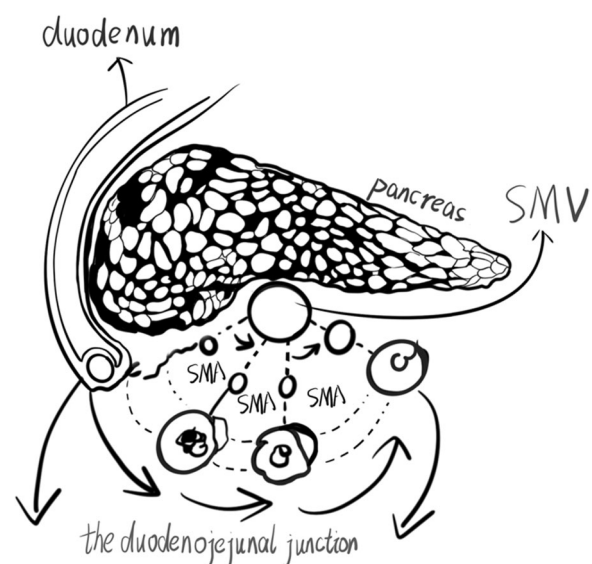


Fig. 5 The SMA appearing to revolve around the SMV on the basis of the location of the duodenojejunal junction

approaches. We believe that for type I right PDH, the incomplete fusion of the ascending mesentery and the dorsal retroperitoneum needs to be resolved. For type II right PDH, the purpose of surgery is to solve the problem that the horizontal part of the duodenum cannot pass through the dorsal side of the superior mesenteric vessel to reach the left side of the vertebral column during embryonic development. To achieve this purpose, medial and lateral approaches can be adopted. At present, the lateral approach is the most used in the literature. The lateral approach is considered to be a simple Ladd's procedure, which does not release the right colon from the hepaticocolic ligament and the greater curvature of the stomach and fails to achieve the purpose of inverting the right colon. The lateral approach only opens the hernia orifice from the outside. This view is also supported by other authors [29, 55]. For type III right PDH, the best solution is the Ladd's procedure, which is also indisputable.

Conclusion

This paper classified right PDH according to anatomical features and embryonic development. Additionally, the surgical methods for different types of right PDH were summarized. The authors believe that this paper will help surgeons improve their understanding of right PDH in their clinical work and choose a rational surgical approach.

Acknowledgements

We would like to express our gratitude to our friend Qian, Xing-Yu, who helped map the anatomical diagrams and surgical paths used in this article.

Author contributions

XLW and ZLJ contributed to the conceptualization, methodology, analysis, manuscript draft, and supervision of the writing process. GXJ, JFW, ZRC, and LMW contributed to the literature and data collection, writing review, and editing of manuscript.

Funding

Not applicable.

Availability of data and materials

Not applicable.

Declarations

Ethics approval and consent to participate

Obtained informed consent signed by patients was obtained for the cases included in this article. The research protocol complied with the ethical standards of the Institutional Research Committee and the 1964 Declaration of Helsinki and its subsequent amendments. As this is a retrospective observational study and reviews the literature, no formal consent to this study is required, nor is approval by the Institutional Research Committee.

Consent for publication

Written informed consent was obtained from the patient for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

Competing interests

The authors declare no competing interests.

Received: 3 August 2023 Accepted: 27 November 2023

Published online: 30 December 2023

References

- Ghahremani GG. Internal abdominal-hernias. *Surg Clin North Am.* 1984;64(2):393–406.
- Takeyama N, *et al.* CT of internal hernias. *Radiographics.* 2005;25(4):997–1015. <https://doi.org/10.1148/rg.254045035>.
- Martin LC, Merkle EM, Thompson WM. Review of internal hernias: radiographic and clinical findings. *Am J Roentgenol.* 2006;186(3):703–17. <https://doi.org/10.2214/ajr.05.0644>.
- Armstrong O, *et al.* Internal hernias: anatomical basis and clinical relevance. *Surg Radiol Anat.* 2007;29(4):333–7. <https://doi.org/10.1007/s00276-007-0212-6>.
- Schizas D, *et al.* Paraduodenal hernias: a systematic review of the literature. *Hernia.* 2019;23:1187–97. <https://doi.org/10.1007/s10029-019-01947-3>.
- Bittner JG IV, *et al.* Laparoscopic repair of a right paraduodenal hernia. *JLS.* 2009;13:242–9.
- Exner FB. The roentgen diagnosis of right paraduodenal hernia—report of a case with survey of the literature. *Am J Roentgenol Radium Ther.* 1933;29:585–99.
- Williams AJ. Roentgen diagnosis of intra-abdominal hernia - an evaluation of the roentgen findings. *Radiology.* 1952;59(6):817–25. <https://doi.org/10.1148/59.6.817>.
- Khan MA, Lo AY, Maele DM. Paraduodenal hernia. *Am Surg.* 1998;64(12):1218–22.
- Zonca P, *et al.* Treitz's hernia. *Hernia.* 2008;12(5):531–4. <https://doi.org/10.1007/s10029-008-0339-3>.
- Blachar A, Federle MP. Internal hernia: an increasingly common cause of small bowel obstruction. *Semin Ultrasound CT MRI.* 2002;23(2):174–83. [https://doi.org/10.1016/s0887-2171\(02\)90003-x](https://doi.org/10.1016/s0887-2171(02)90003-x).
- Shinohara T, Okugawa K, Furuta C. Volvulus of the small intestine caused by right paraduodenal hernia: a case report. *J Pediatr Surg.* 2004;39(2):e8–9. <https://doi.org/10.1016/j.jpedsurg.2003.10.029>.
- Jeong G-A, *et al.* Laparoscopic repair of paraduodenal hernia comparison with conventional open repair. *Surg Laparosc Endosc Percutan Tech.* 2008;18(6):5.
- Lin C-H, Ho Y-J, Lin W-C. Preoperative diagnosis of right paraduodenal hernia by multidetector computed tomography. *J Formos Med Assoc.* 2008;107(6):500–4.
- Meyers MA. Paraduodenal hernias. *Radiologic and arteriographic diagnosis.* *Radiology.* 1970;95(1):29–37. <https://doi.org/10.1148/95.1.29>.
- Fukada T, *et al.* A causal relationship between right paraduodenal hernia and superior mesenteric artery syndrome: a case report. *J Med Case Rep.* 2010;4:159. <https://doi.org/10.1186/1752-1947-4-159>.
- Schwab ME, *et al.* A problem at any age: a case report of congenital malrotation with bowel ischemia in an 84-year-old. *BMC Surg.* 2022;22(1):35. <https://doi.org/10.1186/s12893-022-01482-6>.
- Hassan M, *et al.* A rare case of acute abdomen due to strangulated Waldayer's hernia. *Int J Surg Case Rep.* 2012;3(10):507–9. <https://doi.org/10.1016/j.ijscr.2012.06.007>.
- Liu BL, *et al.* Abdominal separation in an adult male patient with acute abdominal pain. *World J Gastroenterol.* 2010;16(26):3343–6. <https://doi.org/10.3748/wjg.v16.i26.3343>.
- Peru N, Jouvin I, Pocard M. Bowel obstruction due to a right paraduodenal hernia with midgut malrotation. *J Visc Surg.* 2020;157(3):215–6. <https://doi.org/10.1016/j.jviscsurg.2019.08.008>.
- Ong M, *et al.* Case of a strangulated right paraduodenal fossa hernia in a malrotated gut. *BMJ Case Rep.* 2017. <https://doi.org/10.1136/bcr-2017-220645>.
- Yeoman LJ, Patel AG, Michell MJ. Case report: computed tomography appearances in a right paraduodenal hernia. *Clin Radiol.* 1994;49(12):898–900. [https://doi.org/10.1016/s0009-9260\(05\)82889-2](https://doi.org/10.1016/s0009-9260(05)82889-2).

23. Warshauer DM, Mauro MA. CT diagnosis of paraduodenal hernia. *Gastrointest Radiol.* 1992;17(1):13–5. <https://doi.org/10.1007/bf01888498>.
24. Erdas E, *et al.* Diagnosis and treatment of symptomatic right paraduodenal hernia: report of a case. *Surg Today.* 2014;44:192–6. <https://doi.org/10.1007/s00595-012-0483-3>.
25. Indiran V, Maduraimuthu P. Intestinal obstruction due to malrotation of midgut and right paraduodenal hernia. *GE Port J Gastroenterol.* 2016;23(5):276–8. <https://doi.org/10.1016/j.jpge.2015.12.008>.
26. Gupta RK, *et al.* Laparoscopic management of right paraduodenal hernia along with the correction of malrotation in a pediatric patient: a case report. *Ann Pediatr Surg.* 2013;9(2):90–2.
27. Antedomenico E, *et al.* Laparoscopic repair of a right paraduodenal hernia. *Surg Endosc.* 2004;18(1):165–6. <https://doi.org/10.1007/s00464-003-4516-2>.
28. Manipadam JM, *et al.* Laparoscopic repair of a right paraduodenal hernia. *Surg J (N Y).* 2018;4(3):e129–32. <https://doi.org/10.1055/s-0038-1667149>.
29. Walkner S, Nebiker CA. Laparoscopic repair of a right-sided paraduodenal hernia. *J Surg Case Rep.* 2019;2019(12):337. <https://doi.org/10.1093/jscr/rjz337>.
30. Rajesh S, *et al.* Malrotation of small bowel-diagnostic computed tomography (CT) signs and intraoperative findings. *Indian J Surg.* 2015;77(Suppl 2):600–2. <https://doi.org/10.1007/s12262-013-0938-9>.
31. Patel RV, *et al.* Neonatal obstructed Treitz's hernia with abdominal cocoon simulating volvulus neonatorum. *BMJ Case Rep.* 2013. <https://doi.org/10.1136/bcr-2013-009950>.
32. Rampal K, *et al.* Paraduodenal hernia with massive intestinal gangrene and its surgical management: a case report. *Cureus.* 2022;14(11): e32008. <https://doi.org/10.7759/cureus.32008>.
33. Yoo HY, Mergelas J, Seibert DG. Paraduodenal hernia: a treatable cause of upper gastrointestinal tract symptoms. *J Clin Gastroenterol.* 2000;31(3):226–9. <https://doi.org/10.1097/00004836-2000010000-00008>.
34. Coopwood TB, Bricker DL. Paraduodenal hernias. *South Med J.* 1972;65(9):1138–41. <https://doi.org/10.1097/00007611-197209000-00025>.
35. Lamprou V, *et al.* Right paraduodenal hernia as a cause of acute abdominal pain in the emergency department: a case report and review of the literature. *Diagnostics (Basel).* 2022. <https://doi.org/10.3390/diagnostics12112742>.
36. Tomino T, *et al.* Right paraduodenal hernia successfully treated with laparoscopic surgery. *Asian J Endosc Surg.* 2015;8(1):87–90. <https://doi.org/10.1111/ases.12139>.
37. Ismavel VA, *et al.* Right paraduodenal hernia with extensive bowel gangrene treated with staged surgery: a Bogota bag followed by resection in a low-resource setting. *BMJ Case Rep.* 2021. <https://doi.org/10.1136/bcr-2020-239250>.
38. Olearchyk AS, Cogbill CL. Right paraduodenal hernia: case report. *Mill Med.* 1979;144(3):192–4.
39. Liao YH, Lin CH, Lin WC. Right paraduodenal hernia: characteristic MDCT findings. *Abdom Imaging.* 2011;36(2):130–3. <https://doi.org/10.1007/s00261-010-9635-3>.
40. Poudel N, *et al.* Right-sided paraduodenal hernia with malrotation - A case report. *Ann Med Surg (Lond).* 2021;72:103135. <https://doi.org/10.1016/j.amsu.2021.103135>.
41. Abdullah A, *et al.* Small bowel obstruction due to a right-sided paraduodenal hernia: a case report. *Abdom Imaging.* 2010;35:571–3. <https://doi.org/10.1007/s00261-009-9556-1>.
42. Papaziogas B, *et al.* Surgical images: soft tissue. Right paraduodenal hernia. *Can J Surg.* 2004;47(3):195–6.
43. Lee TK, *et al.* Unusual variant of right paraduodenal hernia. *Aust NZ J Surg.* 1990;60(6):483–5. <https://doi.org/10.1111/j.1445-2197.1990.tb07408.x>.
44. Kwan B, Theodore JE, Wong J. Laparoscopic paraduodenal hernia repair with bioabsorbable mesh: a case of a novel technique for a rare cause of bowel obstruction. *Int J Surg Case Rep.* 2020;70:1–4.
45. Willwerth BM, Zollinger RM Jr, Izant RJ Jr. Congenital mesocolic (paraduodenal) hernia. Embryologic basis of repair. *Am J Surg.* 1974;128(3):358–61.
46. Lam G, Clifton MS, Bhatia AM. Right paraduodenal hernia leading to bowel strangulation. *J Pediatr Surg.* 2011;46(10):2032–4. <https://doi.org/10.1016/j.jpedsurg.2011.06.016>.
47. Tang V, *et al.* Internal hernias in children: spectrum of clinical and imaging findings. *Pediatr Radiol.* 2011;41(12):1559–68. <https://doi.org/10.1007/s00247-011-2158-4>.
48. Parsons PB. Paraduodenal hernias. *Am J Roentgenol Radium Ther Nucl Med.* 1953;69(4):563–89.
49. Mehra R, Pujahari AK. Right paraduodenal hernia: report of two cases and review of literature. *Gastroenterol Rep.* 2016;4(2):168–71. <https://doi.org/10.1093/gastro/gou076>.
50. Palanivelu C, *et al.* Laparoscopic management of paraduodenal hernias: mesh and mesh-less repairs. A report of four cases. *Hernia.* 2008;12(6):649–53. <https://doi.org/10.1007/s10029-008-0376-y>.
51. Andrews E. Duodenal hernia—a misnomer. *Surg Gynecol Obstet.* 1923;37:749–50.
52. Ingøe R, Lange P. The Ladd's procedure for correction of intestinal malrotation with volvulus in children. *AORN J.* 2007;85(2):300–8. [https://doi.org/10.1016/s0001-2092\(07\)60040-4](https://doi.org/10.1016/s0001-2092(07)60040-4). (quiz 309-12).
53. Tan V, Kotobi H, Parc Y. Ladd procedure for malrotation with total intestinal volvulus. *J Visc Surg.* 2017;154(3):197–201. <https://doi.org/10.1016/j.jviscsurg.2017.04.002>.
54. Kluth D, Jaeschke-Melli S, Fiegel H. The embryology of gut rotation. *Semin Pediatr Surg.* 2003;12(4):275–9. <https://doi.org/10.1053/j.sempe dsurg.2003.08.009>.
55. Kotobi H, *et al.* Total midgut volvulus in adults with intestinal malrotation. Report of eleven patients. *J Visc Surg.* 2017;154(3):175–83. <https://doi.org/10.1016/j.jviscsurg.2016.06.010>.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Ready to submit your research? Choose BMC and benefit from:

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

At BMC, research is always in progress.

Learn more biomedcentral.com/submissions

