Surgical approach to the suprarenal abdominal aorta

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AIM. *The surgical approach to the pararenal aorta can be performed through a midline laparotomy or retroperitoneal approach. The current paper reports the techniques for the suprarenal aortic approach, through the review of technical literature on this topic.*
METHODS. *Forty-six out of 82 technical papers regarding the surgical approach to the suprarenal aorta were reviewed, focusing on relevant technical details, such as the position of patient, type of incision, aortic approach and anatomical limitations.*
RESULTS. *The left retroperitoneal abdominal approach offers numerous advantages, mainly observing some modifications of the original technique (9th intercostal space incision, short radial frenotomy, section of the inferior mesenteric artery). The traditional transperitoneal access, through a midline or bilateral subcostal incision with retroperitoneal medial visceral rotation, is best indicated when an unrestricted approach to the right iliac arteries is needed, but it can be more challenging in patients with "hostile abdomen", for which a retroperitoneal route is probably more appropriate.*
A more aggressive surgical approach through a 7th-9th space thoracolaparotomy, combined with semicircunferential frenotomy, should be strongly recommended to provide a safe suprarenal aortic aneurysm repair in high risk patients, who often require adjunctive procedures, such as selective visceral perfusion and left heart bypass.
CONCLUSIONS. *Many technical options can be used to approach the suprarenal aorta, but none can be "radicalized". The surgical strategy must be individualized according to the anatomo-clinical characteristics of the patient and aneurysm morphology as well.*

KEY WORDS: Abdominal aorta, Aortic aneurysm, Surgical approach

The surgical approach to the aorta is usually performed through a transperitoneal midline laparotomy, traditionally used for open repair of aortic aneurysms and obstructive aortofemoral revascularization. The retroperitoneal approach for abdominal aortic repair can offer numerous advantages in case of suprarenal extension of the aneurysm as well as in complex cases (inflammatory aneurysm, aneurysm associated with horseshoe kidney, hostile abdomen for previous interventions or presence of stoma). The "classical" surgical principles concerning alternative options for aortic exposure has to be considered as extremely important, mainly when surgery is reserved for complex aneurysms that are not susceptible to the endovascular treatment. Moreover, as a result of wide use of EVAR, many challenging cases of stent-graft failure will need to be treated in the near future, requiring surgical expertise both in elective and emergency setting. On the basis of a previous Editorial Symposium on the pararenal aorta [1], the current paper aims to illustrate the actual techniques for the suprarenal aortic approach, through the review of some seminal contributions of the world literature on this topic.

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Historical background

Although the first aortic aneurysm ligation was performed retroperitoneally in 1834 in Cape Town, South Africa [2] and the first prosthetic correction of an aortic aneurysm was performed retroperitoneally by Dubost in 1952 [3] the midline laparotomy has been traditionally preferred to the retroperitoneal route for aortic repair, despite its limitations in the control of the para-suprarenal tract. Indeed, an unrestricted aorta exposure, through a thoracoabdominal incision and medial visceral rotation anterior to the left kidney, was originally proposed by Debakey, Creech and Morris in 1956 [4], but the merit of having identified a less invasive alternative approach to the pararenal aorta should be recognized to Charles Rob, who used a totally retroperitoneal aortic route in 1952, describing the technical details in 1963 [5]. Other experiences with the Rob's technique were later reported by Stipa and Shaw, mainly to treat obstructive aortic disease [6].

"Classic" retroperitoneal approach

In order to achieve a more extended aortic exposure of the suprarenal tract, Williams and Ricotta proposed some important modifications to the Rob's original technique, in terms of patient's position and type of incision [7-10].
– Position of patient: left thoracotomy (70-80°), with pelvis rotated as horizontally as possible (Fig. 1A).
– Incision: curvilinear, from the medial margin of the rectal muscle, below the umbelicus, to the 10th-12th rib, depending on the need for proximal aorta exposure, with facoltative rib resection (Fig. 1B).
– Approach: retroperitoneal, behind the left kidney with section of the left diaphragmatic crus (Fig. 2), or anterior to the left kidney to have a better control of superior mesenteric artery and right renal artery.
– Limitations: restricted control of the right iliac artery. Using the retroperitoneal approach through the 10th interspace, an excellent exposure of the suprarenal aorta can be obtained, including the distal thoracic aorta. If the pleura is accidentally entered, can be easily repaired at the end of closure.

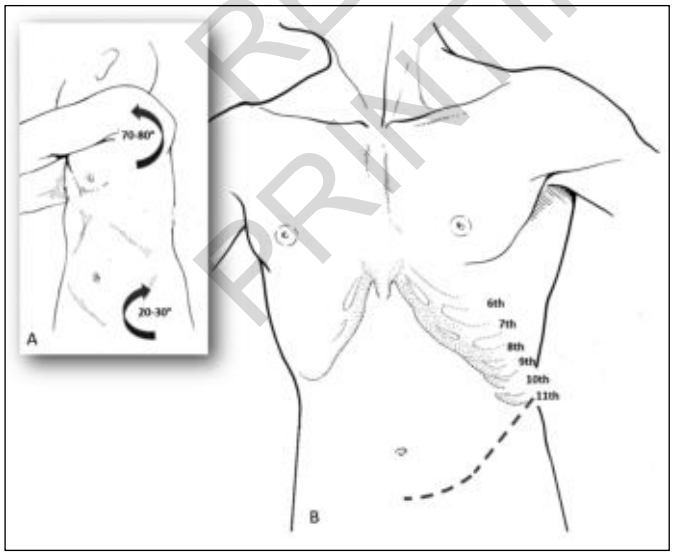

Fig. 1: Retroperitoneal approach according to Williams: A) Position of patient; B) Incision line.

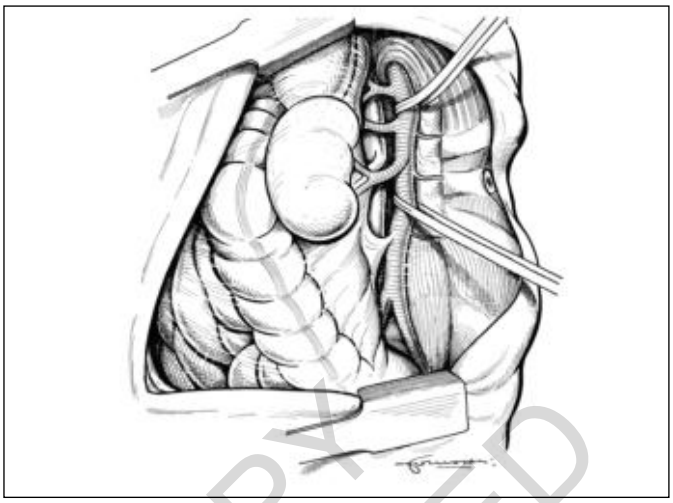

Fig. 2: Retroperitoneal exposure of abdominal aorta, behind the left kidney (10). Reprinted with permission, Società Editrice Universo, Roma 1977

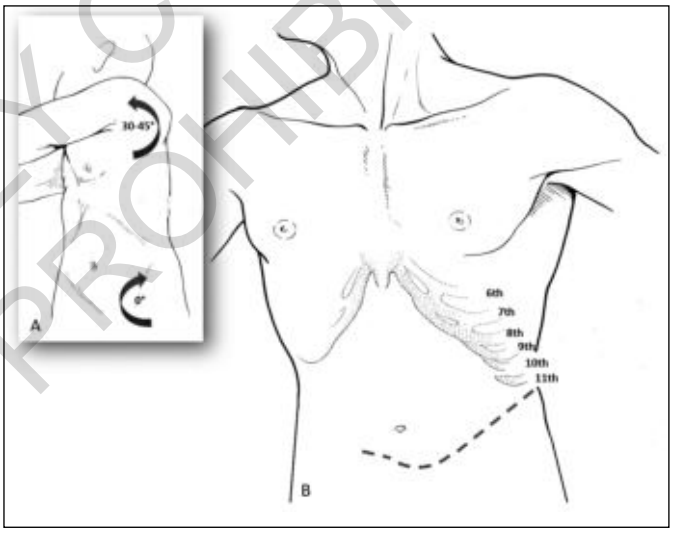

Fig. 3: Retroperitoneal approach according to Sicard: A) Position of patient. B) Incision line.

In 1987 Sicard reported an alternative to the Williams' technique, modifying the incision and the position of patient [11].
– Position of patient: supine, with left chest obliqued at 30-40° (Fig. 3A).
– Incision: curvilinear from the right abdominal quadrant, below the umbelicus, to the 11th-12th rib, passing 5 cm medially to the left superior anterior iliac spine (Fig. 3B).

– Approach: retroperitoneal, anterior to the left kidney, with section of the left diaphragmatic crus and eventual ligature of the inferior mesenteric artery (Fig. 4).
– Limitations: restricted control of the suprarenal aorta. Although, a randomized study by Cambria showed no evidence of superiority of the anterolateral retroperitoneal route described by Sicard [12], later on, Shepard confirmed the advantages of the posterolateral approach according to Williams, to treat complex aortic reconstructions [13]. Similarly, the Albany group reaffirmed the value of the Williams' technique, reporting in 1996 an important series of aortic reconstructions performed retroperitoneally (n. 2340), both in elective and in emergency setting [14]. This group outlined some surgical details concerning the position of patient (left thoracotomy position 45-60°, with pelvis rotated to 20-30°) and other technical specifications to gain a safe retroperitoneal aortic control (management of the lumbar arteries, free mobilization of the left kidney in any direction through the section of the ascending lumbar vein, approach to the right renal artery, surgical route to have a quick suprarenal clamping in case of ruptured aneurysm).

The retroperitoneal approach in the 3rd millennium

The New York group has reported some modifications to the Williams' retroperitoneal approach, with the aim to improve the suprarenal aortic control [15].
– Position of patient: left thoracotomy (Fig. 5A).
– Incision: S-curvilinear, from the lateral margin of the rectus muscle, below the umbelicus, to the 9th intercostal space, with partial resection of the 10th rib, without frenotomy (Fig. 5B).

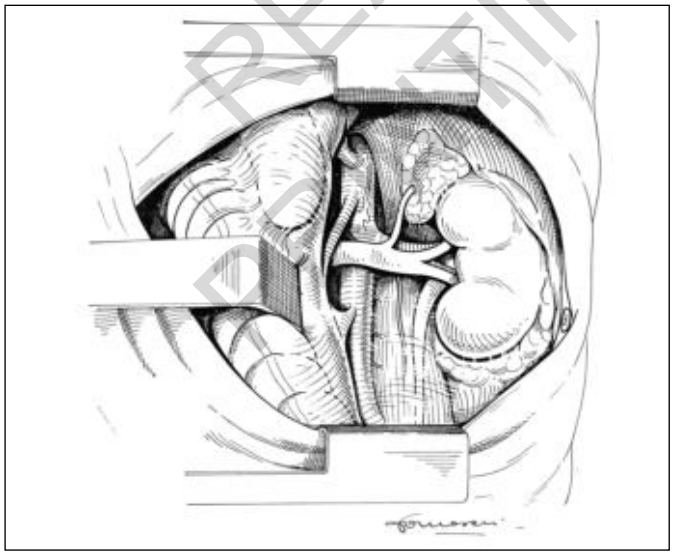

Fig. 4: Retroperitoneal exposure of abdominal aorta, with the left kidney remaining in its bed (10). Reprinted with permission, Società Editrice Universo, Roma 1977

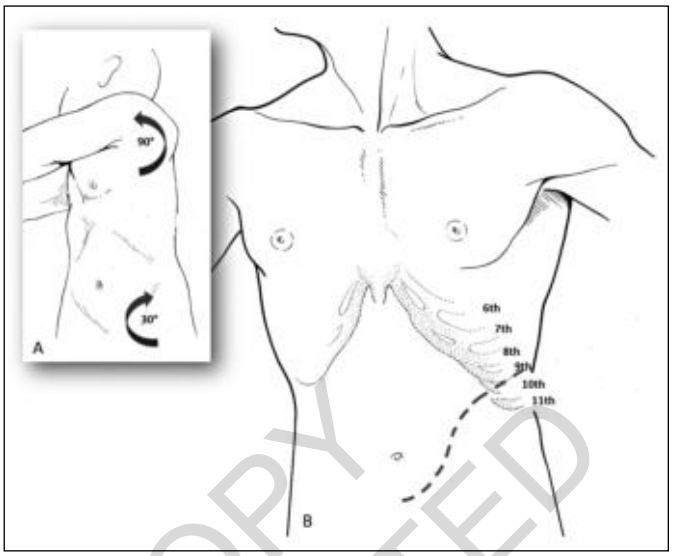

Fig. 5: Retroperitoneal approach according to Shaw: A) Position of patient. B) Incision line.

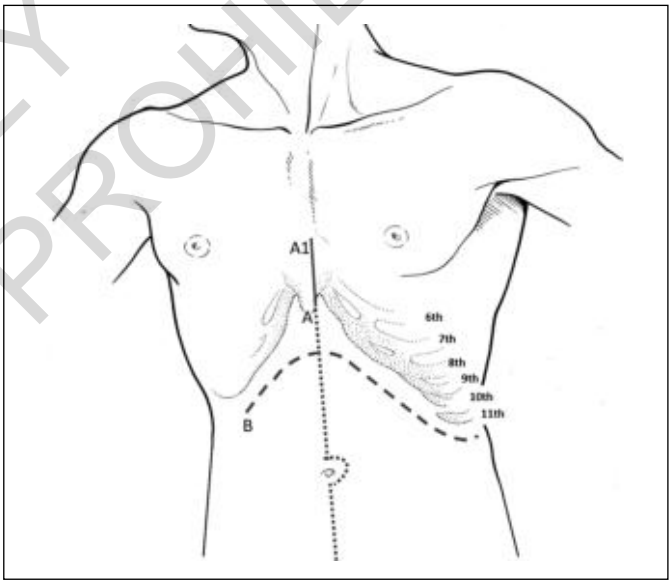

Fig. 6: Laparotomy approach to the abdominal aorta: Midline laparotomy. A1) Upper extension to the third inferior of the sternum. Subcostal bilateral laparotomy (rooftop incision).

– Approach: retroperitoneal, behind the left kidney, with section of the diaphragmatic crus.
– Limitations: restricted control of the right renal artery and right iliac artery (contralateral access to the right iliac axis, if necessary).
Currently the extraperitoneal approach through the 9th intercostal space, is considered to be more appropriate for a safe control of the suprarenal aorta, with reasonable surgical trauma [16,17].
An alternative retroperitoneal route to the aorta, using a midline incision, was initially proposed by Nakajima [19]

in 2000 [18], and recently reintroduced with modifications by the Mayo Clinic group [19]. The procedure consists of a fully extraperitoneal approach through a midline access, that allows a good accessibility to the aorta and bilateral iliac axis, with lesser trauma to the muscle wall compared to the left flank incisions. However, as reported by the same promoters of this technique, this operation needs prolonged surgical times (approximately 9 hours), suggesting a relevant complexity of the procedure [19] . Following the enthusiasm for minimally invasive techniques, a video-assisted retroperitoneal mini-approach has been proposed to treat abdominal aortic aneurysm by the Marseille group [20]. However, this procedure seems to be not completely safe for the suprarenal tract and should be exclusively considered in selected cases of aortic aneurysm.

The laparotomy route

The midline transperitoneal laparotomy does not always allow a safe vascular control of suprarenal aortic aneurysms and hostile aortic neck, leading to clamp-induced injuries and/or embolization in the visceral arteries. Basically, it is possible to provide an extensive proximal, through the division/full mobilization of the left renal vein and supraceliac aortic clamping [21,22], but other surgical options may be considered. An actractive alternative to have a complete abdominal aorta exposure is

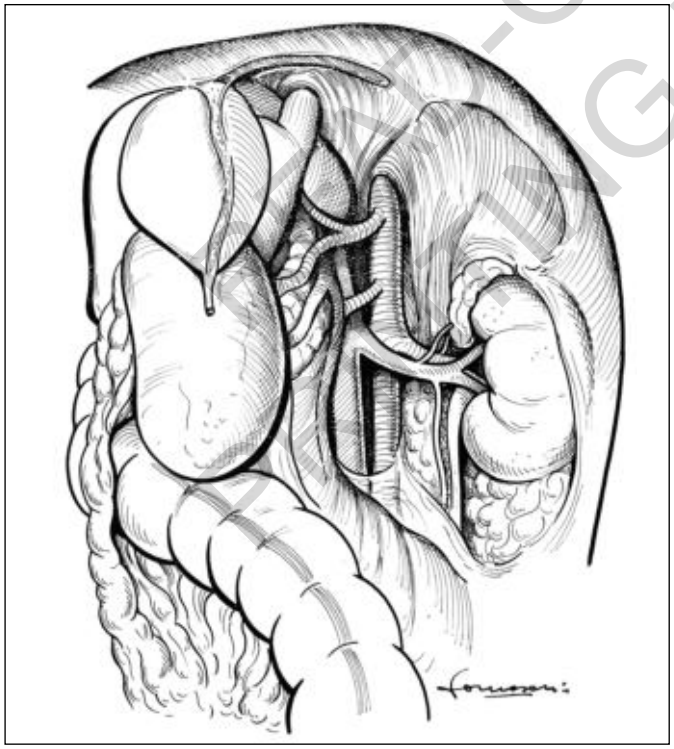

Fig. 7: Left to right medial visceral rotation (MVR), with the left kidney remaining in its bed (10). Reprinted with permission, Società Editrice Universo, Roma 1977.

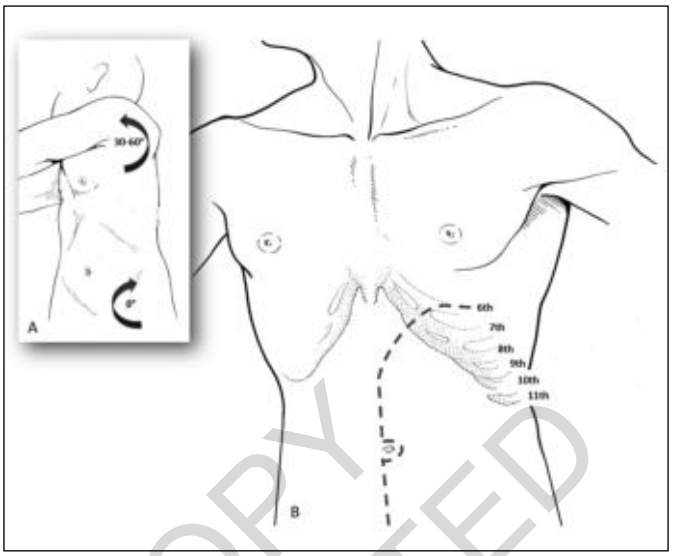

Fig. 8: Laparotomy approach to improve the anatomical exposure during the MVR procedure: A) Position of patient. B) Incision line.

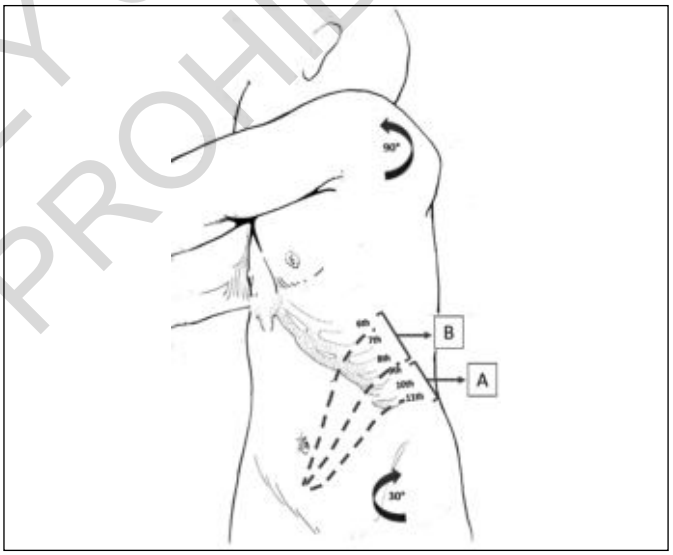

Fig. 9: Thoracolaparotomy approach to Type IV TAAA: Extrapleural route with short radial frenotomy and retroperitoneal visceral rotation. Intrapleural route with semicircular frenotomy and intra/retroperitoneal visceral rotation, with or without visceral perfusion.

the medial visceral rotation (MVR), proposed by Mattox in the 70s and successively popularized by Stoney after an initial experience with the thoraco-retroperitoneal approach [23-26].

– Postion of patient: supine.
– Incision: midline or bilateral subcostal laparotomy (Fig. 6).
– Approach 1: mobilization of the left colon anterior to the kidney, with medial mobilization of the viscera, after section of the peritoneal reflections, including the left triangular ligament (Fig. 7).
– Approach 2: mobilization of the left colon behind the left kidney, with full mobilization of the left renal vein

to have an unrestricted exposure of suprarenal aorta, avoiding the tedious dissection of the periaortic tissue close to superior mesenteric artery and celiac axis.
– Limitations: manipulation of the viscera, length of the procedure.
Eventual iatrogenic damage due to the excessive traction on pancreas and spleen during MVR, can be avoided with the aid of a partial lower sternotomy or an anterolateral thoracotomy to the 6th space and radial section of the diaphragm, as suggested by Kieffer and others [27,28]. According to Cinà and Mastracci [29], a slight elevation of the left chest (30-60°) associated to the 6th intercostal anterolateral incision, may improved the anatomical exposure during the MVR maneuvers performed in supine position Fig. 8. A procedure of MVR can also be used from the right side, by means of full mobilization of the ascending colon and Kocher maneuver, as formerly reported by Cattell and Braasch in 1960 [30], resulting a paracaval aortic approach particularly actractive in case of post-surgical aorto-enteric fistula or major abdominal vascular trauma [31,32].

Approach to type IV thoracoabdominal aneurysm

The most popular approach to type IV thoracoabdominal aortic aneurysm (TAAA) consists of an incision from 9th to 11th rib, associated to a short radial frenotomy and retroperitoneal visceral rotation [33-35]. Conversely, some groups [36-39] prefer a two-cavities approach through an incision from 7th to 9th intercostal space with semicircular frenotomy, which allows a larger surgical site and the possibility of performing adjunctive procedures, such as selective visceral perfusion and left heart bypass (Fig. 9).
John Wolfe proposed in 1995 a full laparotomic approach, through bilateral subcostal access ("rooftop" or "chevron" incision), combined to MVR, in an effort to reduce the respiratory complications after thoracolaparotomy [40]. Despite some issues concerning the aortic exposure and increased blood losses due to the MVR [41], this approach can be used in many patients candidated to open correction of type IV TAAA, mainly in those with favorable anatomy [36,42-44].

Final anatomo-surgical considerations

The surgical strategy to approach the suprarenal aorta must be individualized according to the patient's anatomo-clinical features and aneurysm morphology as well.
The retroperitoneal abdominal approach from the left flank, behind or in front of the left kidney, offers numerous advantages, providing an unobstructed view of the surgical site, with reasonable anatomical trauma. Indeed, the actual modifications of the original technique, such as 9th intercostal space incision, short radial frenotomy and section of the inferior mesenteric artery, make it possible to obtain a safe control of both suprarenal abdominal and distal thoracic aorta, including the first tract of the visceral vessels [15-17].
The traditional transperitoneal surgical access, through a midline or bilateral subcostal incision, allows to isolate the pararenal aorta, by means of an infra- supramesocolic route or, as an alternative, a left MVR [22-29]. These techniques are best indicated when an unrestricted approach to the right iliac arteries is needed, but they can be more challenging in patients with "hostile abdomen" and in presence of narrow sternocostal angle, for which a retroperitoneal route is probably more appropriate [22-29]. A more aggressive surgical approach through a 7th-9th space thoracolaparotomy, combined with semicircunferential frenotomy, should be strongly recommended to provide a safe aortic aneurysm repair in case of extensive suprarenal involvement, not suitable for any kind of surgery confined to the abdomen or in high risk patients who require adjunctive procedures, such as selective visceral perfusion or left heart bypass [34-39,45,46].

Riassunto

L'approccio chirurgico all'aorta pararenale può essere eseguito attraverso una laparotomia mediana o per via retroperitoneale. Dopo aver esaminato 46 articoli di tecnica chirurgica della letteratura per questo tipo di accesso, di 82 consultati, ci siamo concentrati sui dettagli tecnici rilevanti, come la posizione del paziente, il tipo di incisione, l'approccio aortico e le limitazioni anatomiche. I risultati di questa analisi sono a) che l'approccio addominale retroperitoneale sinistro offre numerosi vantaggi, osservando principalmente alcune modifiche della tecnica originale (incisione del 9° spazio intercostale, breve frenotomia radiale, sezione dell'arteria mesenterica inferiore); b) il tradizionale accesso transperitoneale, attraverso un'incisione subcostale mediana o bilaterale con rotazione viscerale mediale retroperitoneale, meglio indicato quando è necessario un approccio senza divaricazione delle arterie iliache destre, ma può essere più impegnativo nei pazienti con "addome ostile", nei quali la via retroperitoneale è probabilmente più appropriata.
Un approccio chirurgico più aggressivo attraverso una toracolaparotomia del 7°-9° spazio, combinato con frenotomia semicirconferenziale, dovrebbe essere fortemente raccomandato per fornire una riparazione sicura dell'aneurisma dell'aorta soprarenale nei pazienti ad alto rischio, che spesso richiedono procedure aggiuntive, come la perfusione viscerale selettiva e il bypass cardiaco sinistro .
Conclusioni. Molte opzioni tecniche possono essere utilizzate per avvicinarsi all'aorta soprarenale, ma nessuna può essere "radicalizzata". La strategia chirurgica deve essere individualizzata in funzione delle caratteristiche anatomo-cliniche del paziente e della morfologia dell'aneurisma.

References

1. *Editorial Symposium. Aneurysms of the pararenal aorta.* Ann Ital Chir, 2004; 75:133-232.

2. Immelman EJ: *Dr. Murray's case of ligature of the abdominal.aorta. Somerset Hospital 1834*. S Afr Med J, 1991; 79:394-96.

3. Dubost C, Allary M, Oeconomos N: *Resection of an aneurysm of the abdominal aorta: Reesstablishment of the continuity by a preserved human arterial graft, with result after five months.* Arch Surg, 1952; 19:405-08.

4. De Bakey ME, Creech O, Morris GC: *Aneurysm of thoracoabdominal aorta involving the celiac, superior mesenteric, and renal arteries. Report of four cases treated by resection and homograft replacement*. Ann Surg, 1956; 144:549-57.

5. Rob C: *Extraperitoneal approach to the abdominal aorta*. Surgery, 1963; 53:87-9.

6. Stipa S, Shaw RS: *Aortoiliac reconstruction through a retroperitoneal approach.* J Cardiovasc Surg, 1968; 9:224-36.

7. Williams GM, Ricotta J, Zinner M, Burdick J: *The extended retroperitoneal approach for treatment of extensive atherosclerosis of the aorta and renal vessels*. Surgery, 1980; 88:846-55.

8. Ricotta JJ, Williams GM: *Endarterectomy of the upper abdominal aorta and visceral arteries through an extraperitoneal approach*. Ann Surg, 1980; 192:633-38.

9. Shepard AD, Scott GR, Mackey WC, O'Donncll TF, Bush HL, Callow AD: *Retroperitoneal approach to high risk abdominal aortic aneurysms.* Arch Surg, 1986; 121:444-48.

10. Picciocchi A, Asole F, Netri G, Calisti A: *La Chirurgia delle Arterie Digestive*. Roma: Società Editrice Universo, 1977, 134-49.

11. Sicard GA, Freeman MB, VanderWoude JC, Anderson CB: *Comparison between the retropcritoncal approach the infrarenal abdominal transabdominal and for reconstruction of aorta.* J Vasc Surg, 1987; 5:19-27.

12. Cambria RP, Brewster DC, Abbott WM, Megerman J, LaMuraglia G, Wilson R, Wilson D, Teplick R, Davison JK: *Transperitoneal versus retroperitoneal approach for aortic reconstruction: A randomized prospective study*. J Vasc Surg, 1990; 11:314-25.

13. Shepard AD, Tollefson DF, Reddy DJ, Evans JR, Elliott JP Jr, Smith RF, Ernst CB: *Left flank retroperitoneal exposure: a technical aid to complex aortic reconstruction*. J Vasc Surg, 1991; 14:283-91.

14. Darling C 3rd, Shah DM, Chang BB, Paty PS, Leather RP: *Current status of the use of retroperitoneal approach for reconstructions of the aorta and its branches*. Ann Surg, 1996; 224:501-06.

15. Shaw PM, Veith FJ, Lipsitz EC, Ohki T, Suggs WD, Mehta M, Freeman K, McKay J, Berdejo GL, Wain RA, Gargiulo Iii NJ: *Open aneurysm repair at an endovascular center: Value of a modified retroperitoneal approach in patients at high risk with difficult aneurysms.* J Vasc Surg, 2003; 38:504-10.

16. Twine CP, Lane IF, Williams IM: *The retroperitoneal approach to the abdominal aorta in the endovascular era.* J Vasc Surg, 2012; 56:834-38.

17. Wang Y, Cui L, Li F, Liu B, Liu C, Zheng Y: *An optimezed retroperitoneal approach for open aortic repair by partially removing the tenth rib without incising the pleura and diaphragm*. J Vasc Surg Cases, 2016; 2:95-100.

18. Nakajima T, Kawazoe K, Komoda K, Sasaki T, Ohsawa S, Kamada T: *Midline retroperitoneal versus midline retroperitoneal approach for abdominal aortic aneurysm repair.* J Vasc Surg, 2000; 32:219-23.

19. Buckarma E, Beckermann J, Gurrieri C, Frodl B, Saran N, Carmody T, Tallarita T: *A midline retroperitoneal approach for complex abdominal aortic repair. Case description and operative technique*. J Vasc Surg Cases Innov Tech, 2022; 8:678-84.

20. Piquet P, Amabile P, Rollet G: *Minimally invasive retroperitoneal approach for the treatment of infrarenal aortic disease*. J Vasc Surg, 2004; 40:455-62.

21. Crawford ES, Beckett WC, Greer MS: *Juxtarenal infrarenal abdominal aortic aneurysm*. Ann Surg, 1986; 203:661-70.

22. Green RM, Ricotta JJ, Ouriel K, DEWeese JA: *Results of supraceliac aortic clamping in difficult elective resection of infrarenal abdominal aortic aneurysm.* J Vasc Surg, 1989; 9:125-34.

23. Mattox KL, McCollum WB, Beall AC Jr, Jordan GL Jr, Debakey ME: *Management of penetrating injuries of the suprarenal aorta*. J Trauma, 1975; 15:808-15.

24. Reilly LM, Ramos TK, Murray SP, Cheng SW, Stoney RJ: *Optimal exposure of the proximal abdominal aorta: A critical appraisal of transabdominal medial visceral rotation*. J Vasc Surg, 1994; 19:375-89.

25. Stoney RJ, Wylie EJ: *Surgical management of arterial lesions of the thoracoabdominal aorta.* Am J Surg, 1973; 126:157-64.

26. Ramos TK, Relly LM, Murray SP, Stoney RJ: *Combined aortorenal reconstruction: Is there an optimum method of exposure?* Eur J Vasc Endovasc Surg, 1998; 15:128-37.

27. Kieffer E: *Chirurgie des aneurysmes de l'aorte thoraco-abdominale*. Encycl Med Chir - Elsiever SAS Paris, *Techniques chirurgicales – Chirurgie vasculaire*, 43-150, 1993:18p.

28. Ruotolo C, Ficarelli I: *Surgical options in Leriche syndrome. In: Tips and Tricks in Open Vascular Surgery,* Ed R Chiesa, C Setacci, PM Castelli: Minerva Medica, 2017; 54-65.

29. Cinà CS, Mastracci T: *Preparazione delle arterie viscerali per aneurisma*. In: *Atlante di Chirurgia delle Arterie*. Ed A. Cavallaro, AV Sterpetti, F Barberini, L Di Marzo, Padova, Piccin Nuova Libraria SpA, 2008; 517-34.

30. Cattell RB, Braasch JW: *A technique for the exposure of the third and fourth portions of the duodenum.* Surg Gynecol Obstet, 1960; 111:378-79.

31. Speziale F, Rizzo L, Fadda GF, Fiorani P, Alfani D, Rossi M: *Surgical approach for the treatment of secondary aortoenteric fistulae*. Eur J Vasc Endovasc Surg, 1998; 16:530-34.

32. Feliciano DV: *Approach to major abdominal vascular injury*. J Vasc Surg, 1988; 7:730-36.

33. Black JH3rd: *Technique for repair of suprarenal and thoracoabdominal aortic aneurysms*. J Vasc Surg, 2009; 50:936-41.

34. Stella A, Paragona O, Freyrie A, Faggioli G, Kapelj S, Spagnolo C, Di Nino G, D'Addato M: *Aneurismi toraco-addominali di IV tipo [Thoraco-abdominal aneurysms of type IV].* Ann Ital Chir, 2004; 75:223-29.

35. Wahlgren CM, Wahlberg E: *Management of thoracoabdominal aneurysm type IV.* Eur J Vasc Endovasc Surg, 2005; 29:116-23.

36. Tshomba Y, Baccellieri D, Mascia D, Kahlberg A, Rinaldi E, Melissano G, Chiesa R: *Open treatment of extent IV thoracoabdominal aortic aneurysms.* J Cardiovasc Surg, 2015; 56:687-97.

37. Patel VI, Ergul E, Conrad MF, Cambria M, LaMuraglia GM, Kwolek CJ, Brewster DC, Cambria RP: *Continued favorable results with open surgical repair of type IV thoracoabdominal aortic aneurysms*. J Vasc Surg, 2011; 53:1492-98.

38. Jacobs MJ, Mommertz G, Koeppel TA, Langer S, Nijenhuis RJ, Mess WH, Schurink GW: *Surgical repair of thoracoabdominal aortic aneurysms*. J Cardiovasc Surg, 2007; 48:49-58.

39. Frederick JR, Woo YJ: *Thoracoabdominal aortic aneurysm*. Ann Cardiothorac Surg, 2012; 1:277-85.

40. Gilling-Smith GL, Wolfe J: *Transabdominal repair of type IV thoraco-abdominal aortic aneurysms*. Eur J Vasc Endovasc Surg, 1995; 9:112-13.

41. Brooks MJ, Bradbury A, Wolfe HN: *Elective repair of type IV thoraco-abdominal aortic aneurysms; experience of a subcostal (transabdominal) approach.* Eur J Vasc Endovasc Surg, 1999; 18:290-93.

42. Richards JM, Nimmo AF, Moores CR, Hansen PA, Murie JA, Chalmers RT: *Contemporary results for open repair of suprarenal and type IV thoracoabdominal aortic aneurysms*. Br J Surg, 2010; 97:45-49.

43. Johns N, Jamieson RW, Ceresa C, Moores C, Nimmo AF, Falah O, Burns PJ, Chalmers RT: *Contemporary outcomes of open repair of thoracoabdominal aortic aneurysm in young patients*. J Cardiothorac Surg, 2014; 9:195.

44. Ventham NT, Johns N, Nimmo AF, Moores C, Burns PJ, Chalmers RT: *Long-term renal outcomes of consecutive patients undergoing open type IV thoracoabdominal aneurysm repair.* Eur J Vasc Endovasc Surg, 2013; 46:638-44.

45. Gabrielli L, Martelli M, Baudo A, Belletti S: *Vie di accesso all'aorta pararenale e sottodiaframmatica [The approach to the infradiaphragmatic and pararenal aorta*]. Ann Ital Chir 2004; 75:151-56.

46. Chiesa R, Marone EM, Brioschi C, Frigerio S, Tshomba Y, Melissano G: *Open repair of pararenal aortic aneurysms. Operative management, early results, and risk factor analysis.* Ann Vasc Surg, 2006; 20:739-45.