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ΣΧΟΛΗ ΕΠΙΣΤΗΜΩΝ ΥΓΕΙΑΣ

ΙΑΤΡΙΚΗ ΣΧΟΛΗ

ΚΟΙΝΟ ΠΡΟΓΡΑΜΜΑ ΜΕΤΑΠΤΥΧΙΑΚΩΝ ΣΠΟΥΔΩΝ

«ΕΝΔΑΓΓΕΙΑΚΕΣ ΤΕΧΝΙΚΕΣ»

ΕΘΝΙΚΟ ΚΑΙ ΚΑΠΟΔΙΣΤΡΙΑΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ

ΙΑΤΡΙΚΗ ΣΧΟΛΗ ΣΕ ΣΥΝΕΡΓΑΣΙΑ ΜΕ ΤΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΤΟΥ ΜΙΛΑΝΟΥ-
ΒΙCΟCCA

ΔΙΠΛΩΜΑΤΙΚΗ ΕΡΓΑΣΙΑ

ΘΕΜΑ: ΑΝΤΙΜΕΤΩΠΙΣΗ ΕΝΔΟΔΙΑΦΥΓΗΣ ΤΥΠΟΥ II ΜΕΤΑ ΑΠΟ ΕΝΔΑΓΓΕΙΑΚΗ
ΑΠΟΚΑΤΑΣΤΑΣΗ ΑΝΕΥΡΥΣΜΑΤΟΣ ΚΟΙΛΙΑΚΗΣ ΑΟΡΤΗΣ: ΣΥΣΤΗΜΑΤΙΚΗ
ΑΝΑΣΚΟΠΗΣΗ ΤΗΣ ΒΙΒΛΙΟΓΡΑΦΙΑΣ

ΜΕΤΑΠΤΥΧΙΑΚΟΣ ΦΟΙΤΗΤΗΣ: ΚΑΣΤΡΗΣΙΟΣ ΓΕΩΡΓΙΟΣ

ΑΘΗΝΑ

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ΠΡΟΛΟΓΟΣ

Η παρούσα διπλωματική εργασία εκπονήθηκε στα πλαίσια του Κοινού Προγράμματος Μεταπτυχιακών Σπουδών (ΚΠΜΣ) με θέμα «ΕΝΔΑΓΓΕΙΑΚΕΣ ΤΕΧΝΙΚΕΣ», το οποίο διεξάγεται υπό την αιγίδα της Ιατρικής Σχολής του ΕΚΠΑ σε συνεργασία με το Πανεπιστήμιο του Μιλάνου – BICOCCA.

Σκοπός της εργασίας είναι η αξιολόγηση – μέσω συστηματικής βιβλιογραφικής ανασκόπησης – της αποτελεσματικότητας των κύριων θεραπευτικών μεθόδων αντιμετώπισης της ενδοδιαφυγής τύπου II μετά από ενδαγγειακή αποκατάσταση ανευρύσματος κοιλιακής αορτής.

Διευθυντής του μεταπτυχιακού προγράμματος είναι ο Καθηγητής Αγγειοχειρουργικής του ΕΚΠΑ Δρ. Ιωάννης Κακίσης, τον οποίο ευχαριστώ θερμά για την επίβλεψη και αρωγή στην συγγραφή της εργασίας.

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Treatment of type II endoleak following endovascular aortic repair: A systematic review

Abstract

Background: Type II endoleak is the most common type of endoleak following endovascular aortic repair. It usually has a benign course and resolves spontaneously. Nevertheless, persistent type II endoleak has been associated to sac expansion, need for re-intervention and in rare cases rupture. Current practice suggests an endovascular first approach for treating persistent type II endoleaks associated to sac expansion. However, there is no consensus on which method to choose across a wide variety. The aim of this review was to assess the current available literature regarding translumbar, transarterial and transcaval embolization for persistent type II endoleak after endovascular aortic repair.

Methods: A review of the available literature was conducted from January 2018 to December 2023, using Pubmed and EMBASE via Ovid. The PRISMA guidelines were followed. Studies reporting transarterial, translumbar and transcaval embolization for type II endoleak following endovascular aortic repair were included in the analysis. Studies that reported open surgical repair or combination of the previously mentioned endovascular techniques and studies with less than 10 patients, were excluded from the analysis.

Results: A total of 13 studies were included in our analysis. The studies were distributed in three different groups regarding the technique that was used. Six studies were enrolled in Group A, translumbar embolization, four studies in Group B, transarterial embolization, and three studies in Group C, transcaval embolization. Totally, 164 patients were included in Group A while the 73.7% were males. Technical success in Group A was 98% and endoleak resolution rate was 83%. 30-day mortality was 0% and complications rate was 3%. The re-intervention rate in this group was 9.1%. In Group B a total of 118 patients were included. Technical success of transarterial embolization was 90% while endoleak resolution rate was 38%. 30-day mortality was 0% and complications rate was 7.9%. Nearly half of the patients included in this group needed further intervention and thus re-intervention rate was 44%. In

Group C, 46 patients included while 91% were males. Technical success was 98%. 30-d mortality rate and complications rate were 0%. Endoleak resolution rate was 86% and re-intervention rate was 9%.

Conclusion: Translumbar, transarterial and transcaval embolization for persistent type II endoleak present high technical success, low mortality rates and acceptable perioperative complications. Among the three approaches, patients that are treated with transarterial embolization will probably need further intervention in order to achieve sac stabilization and endoleak resolution, compared to the other two endovascular approaches.

Introduction

Type II endoleak (T2EL) after endovascular aortic repair (EVAR) is defined as persistent sac filling from back-bleeding side branches including inferior mesenteric artery (IMA), lumbar arteries (LAs) and middle sacral artery (MSA). Post-operative CT scan reveals T2ELs in 10% to 20% of patients following EVAR.¹⁻⁴ In comparison with type I and III endoleaks, T2ELs usually have a benign course and could be resolved spontaneously within 6 to 12 months after the initial procedure. Therefore, the current guidelines of European society of vascular surgery recommends that type II endoleaks should be treated only when they are accompanied with significant sac expansion (≥ 10 mm compared with baseline or with the smallest diameter during follow up using the same imaging modality and measurement method)⁵. Several risk factors have been reported in the literature for persistent or secondary T2ELs and these include absence of circumferential thrombus in the aneurysm sac or large flow lumen, number of patent aortic side branches arising from AAA, IMA patency, number of patent LAs >3 , diameter of LAs >2 mm and anticoagulant therapy. Although these type of endoleaks are benign, rupture has been described⁶. Rupture rate in the literature seems to be low but it is based on studies where intervention has been performed due to persistent T2EL, thus the true natural history is unknown. It remains unknown which is the optimal treatment for T2ELs. Both endovascular and open surgical techniques have previously been described. A variety of endovascular techniques are available and consist of transarterial, translumbar, transcaval, transgraft and direct sac puncture embolization of feeding vessels. According to the literature, although high technical success is

associated with the previously mentioned techniques, high rates of recurrence are frequent too^{7,8}. Different embolic agents have been used during the past years and include coils and liquid embolic agents (N-butyl cyanoacrylate glue, onyx etc.) Transarterial approach can be performed via the marginal artery of Drummond and the iliolumbar arteries. Transcaval embolization uses the inferior vena cava in order to puncture the aneurysm sac using a TIPS needle. Lastly, the translumbar approach requires the use of CT and fluoroscopy in order to directly puncture the aneurysm sac. On the other hand, open surgical techniques consist of laparoscopic ligation of the IMA or lumbar arteries and open ligation of side branches and suturing the ostia of feeding vessels after opening the aneurysm sac with or without graft explantation. The latter appears to be a more aggressive technique and should be considered after endovascular interventions have failed. It is well understood that an endovascular first approach should be preferred in complications of endovascular aortic repair, such as T2ELs, needing interventional management. The aim of this systematic review was to assess the currently available literature on transarterial, translumbar and transcaval embolization in T2EL needing intervention following endovascular aortic repair.

Material and Methods

Review protocol

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) 2020 Guidelines for Systematic Reviews and Meta-analyses were followed⁹. Due to the nature of the study, no patients were involved and no informed consent or institutional review board approval was required.

Search strategy

A review of the literature was conducted, using Pubmed and Embase via Ovid, from January 2018 to December 2023. The following search terms including Expanded Medical Subject Heading – MeSH were utilized in various combinations: “type II endoleak”, “endovascular treatment”, “transarterial”, “trascaval”, “translumbar” and “embolization”.

Study selection

Studies that were included in the review were those reporting T2EL embolization using the transarterial, the translumbar and the transcaval approach in patients who had previously undergone endovascular aortic repair for abdominal aortic aneurysm. Studies reporting on different approaches than those previously mentioned or combination of endovascular techniques were excluded. Exclusion criteria also included studies with less than 10 patients and any meta-analysis. Primary selection was based on title and abstracts, while the final selection was performed through a full text review.

Data extraction

Extracted data included study characteristics such as author, date of publication, journal of publication, type of study and study period. In addition several information were collected including demographics (age, sex), number of patients, indication for treatment, type of anesthesia, embolic agents used, mean sac diameter at the time of T2EL diagnosis, mean time to intervention, technical success, follow up, endoleak resolution with sac stabilization during follow up, persistent T2EL, reintervention, rupture during follow up period, perioperative mortality and associated complications. Due to the nature of the study the patients were categorized into three different groups depending on the approach that was used (transarterial, translumbar or transcaval).

Outcomes

The primary outcomes were technical success, resolution of T2EL with sac stabilization and perioperative mortality. Secondary outcomes included procedure related complications and the need for reintervention during the follow up period.

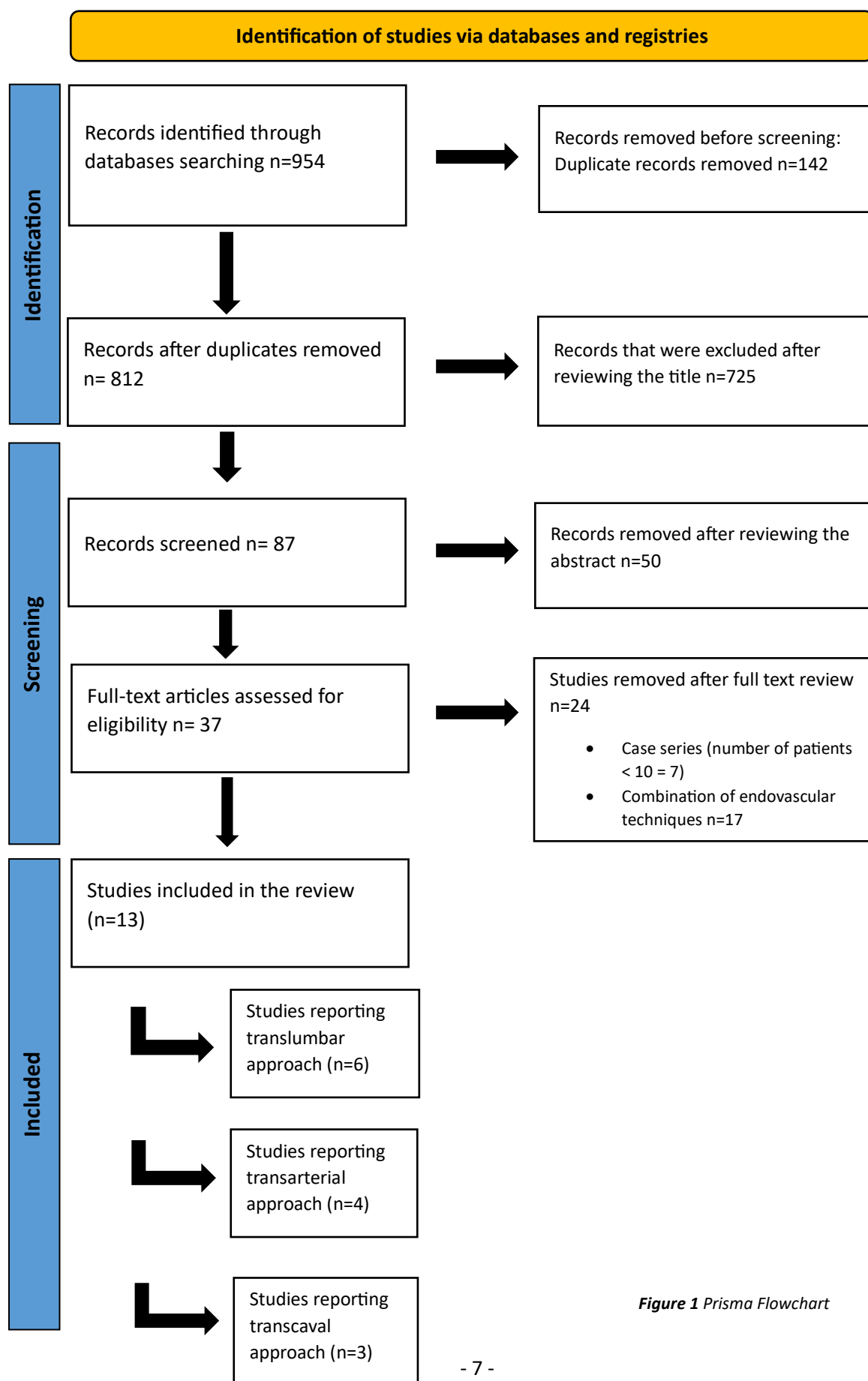


Figure 1 Prisma Flowchart

Results

Initially, 954 articles were identified from databases potentially suitable for inclusion. After removal of duplicates, title, abstract review and finally full-text review a total of 13 studies were included in our cohort. (Figure 1). The distribution of the studies was performed regarding the endovascular approach that was used.

Group A – Translumbar embolization

Six studies published from January 2018 to December 2023 met our inclusion criteria concerning patients treated with translumbar embolization (TLE). A total of 164 patients were included in this group while the 73.7% were males. The mean age of patients was 73.6 years. Other characteristics of the studies and patients enrolled are described in figure 2. In nearly all patients the prone position was used. General anesthesia was chosen in 45% of the patients while the rest were treated with local anesthesia plus sedation. The embolic agent that was used is shown in figure 3. Mean diameter of aneurysm sac at the time of diagnosis of T2EL was 60.4mm and the mean time to intervention after endovascular aortic repair was 24.3 months. Technical success was defined per study. According to the definition of technical success in each study, a total of 98% was achieved overall. Although technical success was high, endoleak resolution with sac stabilization was shown in 83% of the patients with the remaining 17% of the patients experiencing persistent T2EL. The 30-day mortality was 0% and no ruptures were stated after the translumbar approach. Procedure related complications were noted in 3% of the patients and were minor complications without needing further interventions. (infiltration of psoas muscle with embolic material in 2 patients, small subsegmental lung embolism with embolic agent in 1 patient and psoas abscess in 1 patient treated with oral antibiotics). Re-intervention rate was 9.1%, with the vast majority of the patients be treated with endovascular means (translumbar approach). One patient was treated eventually with open sacotomy and ligation of the lumbar arteries with graft preservation. The mean follow-up after embolization was 12.9 months. Reported outcomes are shown in figure 4A and figure 4B.

Author	Date	Journal	Type of study	Study period	Number of patients	Mean Age	M:F	Indication
Charitable et al ¹⁰	2021	Journal of Vascular surgery	Retrospective	2011-2018	30	74.3 (70.9-77.6)	24:6	Persistent isolated T2EL , visible contrast nidus in venous phase , sac growth \geq 5mm
Fanelli et al ¹¹	2020	La radiologia medica	Prospective study	NR	50	63 +/- 8 years	31:19	T2EL, sac enlargement >5mm in the last 6 months
Lagios et al ¹²	2018	J Vasc Interv Radiol	Retrospective study	2009-2012	25	75.5 (64-87)	23:2	T2EL after EVAR with sac expansion >5mm detected with 6mo follow up or later
Leati et al ¹³	2023	Fradi radiology	Retrospective study	2017-2020	10	76 (64-84)	9:1	Persistent T2E with an increase of the aneurysm sac \geq 5 mm on at least one out of 2 axial diameters measured on CTA in a minimum interval of 6 months
Rhee et al ¹⁴	2020	Journal of Vascular surgery	Retrospective study	2015-2017	26	75.27 +/- 8.5 (59-95)	19:7	Present T2EL with sac expansion or symptoms after EVAR
Thomas et al ¹⁵	2020	Vascular and endovascular surgery	Retrospective study	2006-2018	23	78 (67-94)	14:9	Persistent T2EL more than 6mo and significant sac growth > 5mm
Overall					164	73.6	121:44	

Figure 2 Studies and patient's characteristics in TLE group

Author	Position	Anesthesia	Embolic agent	Mean maxSac diameter at T2EL diagnosis	Mean time to intervention	Mean Sac Growth
Charitable et al ¹⁰	Prone	28/30 general, 2/30 sedation + local	n-butyl cyanoacrylate glue (CyG)(Trufill glue, DePuy Synthes; West Chester, Pa) 28/30, CyG + coil 2/30	58mm (54-62)	33.7 +/- 28mo	8.4 mm
Fanelli et al ¹¹	Prone/Supine	Local + sedation 50/50	Onyx +/- detachable micro-coils (Concerto-Medtronic, Minneapolis, MN, US A) (31/50 = 62%) - onyx (19 cases = 38%)	65 +/- 3 (onyx plus coils), 50+/-3 onyx	27 mo (6-48)	NR
Lagios et al ¹²	Prone	Local 25/25	N-butyl cyanoacrylate glue diluted with ethiodized oil	NR	NR	7 x 5 mm
Leati et al ¹³	Prone	local +/- sedation 10/10	iodized Polyvinyl Alcohol Polymer liquid agent (Easyx) +/- coils (Concerto coils Medtronic, Minneapolis, USA)	NR	23 mo (6-47)	NR
Rhee et al ¹⁴	Prone	18/26 general	COILS (6/26) , coils + onyx/glue(n-butyl cyanoacrylate) 20/26	60.3 +/- 7.5mm	13.4 mo (1-63.8)	10.1 +/- 6.5mm
Thomas et al ¹⁵	Prone	27/27 General anesthesia	Glue 10/27, Onyx 12/27, 1 Glue + coils, 4 Onyx + coils	NR	NR	NR
Overall		73/164 (45%) General anesthesia ,91/164 (55%) local plus sedation		60.4mm	24.3 mo	

Figure 3. Procedure characteristics in TLE group

Author	Technical Success	Rupture after TLE	Symptomatic through study period	Endoleak resolution	Persistent T2EL after TLE
Charitable et al ¹⁰	Glue filling the nidus as well as the inflow/outflow vessels 30/30 (100%)	0/30	0/30	15/30 (50%)	15/30 (50%)
Fanelli et al ¹¹	Complete embolization of the aneurysm sac with no more evidence of blood flow within the sac 50/50 (100%)	NR	NR	48/50(96%)	2/50 (4%)
Lagios et al ¹²	Complete embolization of the contributing vessels, 22/25 (88%) and a secondary goal was embolization of the patent portion of the aneurysm sac of the endoleak	NR	NR	22/25 (88%)	3/25 (12%)
Leati et al ¹³	Embolization of the endoleak nidus with reduction or elimination of the T2E on sequent CTA evaluation (10/10 100%). Clinical success was defined as an unchanged or decreased aneurysm sac on a follow-up CTA made during the follow-up, with the first one made after 6 month 9/10 (90%)	0/10	1/10 (10%)	9/10 90%	1/10 10% - open conversion - stent graft explantation - symptomatic
Rhee et al ¹⁴	Successful entry into the target endoleak region and placement of embolization agents into the defined endoleak region. 26/26 (100%)	0/26	2/26 (7.6%)	19/26 reduce in sac size (0.2mm - 19.1mm), 5/26 no sac change, 2 sac growth 3.4 to 4.3 mm with no visible T2EL	3/26 (11.5%) , 1 underwent repeated TLE
Thomas et al ¹⁵	Complete “on table” embolization of the endoleak on fluoroscopy 23/23 100%	0/23	NR	19/23	4 of 23 (sac stabilization after repeated TLE)
Overall	161/164 (98%)	0%	3/66 (4.5%)	137/164 (83%)	28/164 (17%)

Figure 4A. Outcomes in the TLE group

Author	30d mortality	Complications	Mean FU after TLE	Sac stabilization during FU	Re - intervention
Charitable et al ¹⁰	0/30	0/30	19.1 mo (11.1 - 27.2)	11/30 (36.7%) or 11/15 (73.3%)	4/30 (13.3%) {3 TLE with sac stabilization, 1 open sacotomy ligation of lumbar arteries with graft preservation
Fanelli et al ¹¹	0/50	0/50	12 mo	34/50 (68%) sac shrinkage , 16/50 (32%) sac stabilization	2/50 (4%) - percutaneous approach - complete resolution (9 and 12 months)
Lagios et al ¹²	0/25	2/25 (8%) Infiltration of the psoas muscle with embolic material - fever - iv paracetamol for 24h, pos paracetamol for 3d	18.3 +/-7.3 mo (7-42mo)	22/25	3/25 (TLE with N cyano glue)
Leati et al ¹³	0/10	small subsegmental lung embolism - embolic material	14 mo (3-30)	9/10 (90%)	1/10 10%
Rhee et al ¹⁴	0/26	NR	7.1mo (5.9- 10.6mo)	24/26	1/26
Thomas et al ¹⁵	0/23	1/23 (psoas abscess, oral antibiotics)	7.3mo (1-32mo)	19/23	4/23 (TLE)
Overall	0/164 (0%)	4/138 (3%)	12.9 mo	-	15/164 (9.1%)

Figure 4B. Outcomes in the TLE group (continue)

Group B – Transarterial embolization

Four studies, reporting patients treated with transarterial embolization (TAE) for T2EL following endovascular aortic repair, included in our analysis. A total of 118 patients included and 84.4% of these patients were males. The mean age was 75.5 years. Indication for treatment and further characteristics of the studies are described in figure 5. Embolic agents used, consisted of detachable coils in most of the patients, onyx and other liquid agents (figure 6).

Author	Date	Journal	Type of study	Study period	Number of patients	Mean Age	M:F	Indication
Azofra et al. ¹⁶	2019	Annals of vascular surgery	Retrospective	2003-2017	28	NR	NR	Persistent T2E with associated aneurysmal sac growth over 5 mm
Horinouchi et al. ¹⁷	2020	Cardiovasc Intervent Radiol	Retrospective	2010-2018	55	79.0 (74-82)	48:07	Persistent T2EL with sac enlargement >5mm
Moosavi et al. ¹⁸	2023	Vascular	Retrospective	2015-2020	23	78.8 +/- 6.9	20:03	Persistent or recurrent T2EL and interval increase in aneurysm sac size by ≥ 0.5 cm
Tao et al. ¹⁹	2022	Journal of vascular surgery	Retrospective	2015-2020	12	69.5 +/- 14.4	8:04	Persistent T2EL and post-EVAR aneurysm growth of >10mm
Overall	-	-	-	-	118	75.7	76:14	-

Figure 5. *Studies and patients' characteristics in TAE group*

Author	Position	Anesthesia	Target Vessel - IMA	Target Vessel - LAs	Other target vessels	Embolitic material	Mean maxSac diameter at T2EL diagnosis	Mean time to intervention	Mean Sac Growth
Azofra et al ¹⁶	NR	NR	14/28	14/28	0/28	Onyx (ev3 Endovascular, Inc, Plymouth, MN), usually combined with Concerto coils (Covidien-ev3, Irvine, CA)	73.5 +/- 1 mm	37.9mo (1m - 9.3 y)	NR
Horinouchi et al ¹⁷	NR	NR	NR	NR	NR	Coils + NBCA glue (46/55 = 84%), coils 9/55 16%	55 (49-59)	33mo (22-48)	6mm
Moosavi et al ¹⁸	NR	NR	5/23	8/23	1/23 Medial Sacral, 9/23 Iliolumbar	Coils 10/23(43.5%) , Glue 7/23 (30.4%), coils +glue2/23 (8.7%), coils+gelfoam 3/23 (13%), coils+thrombin 1/23 (4.3%)	61 +/- 10 mm (52-95)	NR	NR
Tao et al ¹⁹	Supine	local	5/12	6/12	3/12 IIA	Coils (8/12), Onyx glue (2/12), fibrin sealant (3/12)	71 +/- 11mm	38.4 mo +/- 27.6 mo	23.1 +/- 8.2mm
Overall	-	-	24/63 (38%)	28/63 (44.4%)	-	-	65.1 mm	36.4mo	-

Figure 6. Procedure characteristics in TAE group

In 38% target vessel was the inferior mesenteric artery and in 44.4% were lumbar arteries. Other target vessels included medial sacral artery, iliolumbar arteries and in 3 patients the hypogastric artery. Mean sac diameter at the time of diagnosis of T2EL was 65.1mm and mean time to intervention was 36.4 months. As in group A, definition of technical success was different per study but in total technical success rate was 90%. 30-day mortality was 0% and complications were minor with a rate of 7.9%. Complications included femoral nerve neurapraxia, transient acute renal dysfunction, superior rectal artery embolization with concomitant rectal bleeding and abdominal abscess but no further intervention needed. As it was mentioned above technical success was 90%. However, endoleak resolution was achieved only in 38% of the patients. From the 72 patients with persistent T2EL (62%), 52 (44%) needed re-intervention after TAE. 12% of

the patients underwent open repair with or without graft preservation during the follow up period. Rupture rate after TAE was 2.5% and aneurysm related death was 4% (Figure 7A, 7B).

Author	Technical Success	Rupture after TAE	Symptomatic through study period	Endoleak resolution	Persistent T2EL after TAE	Mean FU after TAE
Azofra et al ¹⁶	Angiographic eradication of the endoleak in the final postprocedural control - 20/28 (71.4%)	3/28 (10.7%)	NR	11/28 (39.3%)	17/28 (60.7%)	25.5 mo
Horinouchi et al ¹⁷	No detectable endoleak nidus at the completion angiogram (100%)	0/55	NR	16/55 (29%)	39/55 (71%)	21.2 mo (14.8-43)
Moosavi et al ¹⁸	Complete endoleak embolization on intraprocedural fluoroscopy 20/23 (86.9%)	0/23	NR	11/23 (48%)	12/23 (52%)	26.5 +/- 15.4 (6-48) mo
Tao et al ¹⁹	11 of 12 (1 inaccessible transarterial approach)	0/12	0/12	7/12 (58%)	4/12 (2/4 with sac expansion)	35.9 +/- 21.1 mo
Overall	106/118 (90%)	3/118 (2.5%)	-	45/118 (38%)	72/118 (62%)	27.2 mo

Figure 7A. Outcomes in the TAE group

Author	30d mortality	Complications	Sac stabilization during FU	Re - intervention	Aneurysm related death at fu	Open conversion during FU
Azofra et al ¹⁶	0/28	2/28 (7.1%) – ½ neurapraxia of femoral nerve, ½ transient acute renal dysfunction	18/28 (64.2%) - 1y	10/28 (35.7%)	4/28 (14.3)	1/28 (7.1%)
Horinouchi et al ¹⁷	0/55	NR	73.2% (1y), 32% at 3, 26.7% at 5	29/55 (52.7)	0/55	11/55 (20%), 1/55 open ligation
Moosavi et al ¹⁸	0/23	2/23 (8.7%) (superior rectal artery embolization-rectal bleeding 1/2, anterolateral thigh pain 1/2)	6/18 (33.3%)	10/23 (43%) (6 direct sac puncture, 2 graft relining, 2 TAE)	NR	NR
Tao et al ¹⁹	0/12	1/12 (8.3%) - abdominal abscess	8/ 12 66.7%	3/12 (25%)	0/12	0/12
Overall	0/118 (0%)	5/63 (7.9%)	-	52/118 (44%)	4/95 (4%)	12/96 (12%)

Figure 7B. Outcomes in the TAE group (continue)

Group C – Transcaval embolization

Limited publications were found during the review of the literature, reporting transcaval embolization (TCE) for T2EL, thus only three studies were included. 46 patients were included in this group. 91% of the patients were males and the mean age was 79.3 years (Figure 8).

Author	Date	Journal	Type of study	Study period	Number of patients	Mean Age	M:F	Indication
Burley et al. ²⁰	2019	Journal of Vascular surgery	Case series	2017	10	82 +/- 7 (72-93)	8:2	T2EL
Heidemann et al. ²¹	2020	Journal of Vascular surgery	Retrospective cohort	2015-2019	24	76.6 +/- 6.0	23:1	T2EL and sac growth > 5mm
Ryer et al. ²²	2021	J Vasc Surg Cases Innov Tech	Retrospective cohort	2019-2021	12	NR	NR	NR
Overall	-	-	-	-	46	79.3	31:3	-

Figure 8. Studies and patients' characteristics

All the patients were treated using the supine position and access was gained through the right common femoral vein in 98%. In one of the including studies, 53% of the patients, further arterial access was gained through femoral artery. 71% of the patients were treated under general anesthesia while the rest were under local anesthesia plus sedation. Target vessels were included lumbar arteries in 91% and inferior mesenteric artery in 9%. The types of embolic agents that were used can be shown in figure 9. Mean sac diameter was 71.3mm at the time of diagnosis of T2EL while mean time to intervention was 56.3 months. Technical success was quite high with a rate of 98%. No ruptures reported after TCE and endoleak resolution was achieved in 86%. 30-day mortality was 0% and no complications were reported. Sac stabilization during follow up after TCE was achieved in 91%. The re-intervention rate was 9%. One patient needed further treatment with TAE and the other three patients were treated with open surgical repair thus open conversion during follow up period was 7%. (Figure 10)

Author	Position - Access vessels	Anesthesia	Target Vessel - IMA	Target Vessel - LAs	Other target vessels	Embolic material	Mean maxSac diameter at T2EL diagnosis	Mean time to intervention	Mean Sac Growth
Burley et al ²⁰	Supine (10/10)- RCFV access (10/10)	8/10 general, 2/10 sedation + local	0/10	10/10	NR	Coils, 10/12 (plus fibrin sealant)	NR	NR	12mm
Heiderman et al ²¹	Supine (25/25) - RCFV access (25/25) - Femoral Artery access (25/25)	7/25 (28%) local, 18/25 (72%) general	IMA + LA 2/24, LA + IMA + accessory RA 1/24	22/25	NR	Bioactive coils 25/25, histoacryl glue 16/25, fibrin sealant (1/25), vascular plug (2/25), oils, n-butyl-2-cyanoacrylate, Lipiodol, (Guerbet, FR), Fibrin sealant	74 +/- 11.8mm	30 mo (7 - 84mo)	NR
Ryer et al ²²	Supine (12/12) - RCFV 11/12 (92%), LCFV 1/12 (8%)	6/12 (50%) general, 6/12 sedation + local	NR	NR	NR	Coils, 10/12 +/- fibrin sealant	68.6 +/- 11.8mm	82.6 +/- 56.1mo	NR
Overall	Supine 47/47, RCFV 46/47 (98%), 25/47 (53%) Femoral Artery access	32/45 (71%) general anesthesia	3/35(9%)	32/35 (91%)	-	-	71.3 mm	56.3 mo	-

Figure 9. Procedure characteristics in TCE group

Author	Technical Success	Rupture after TCE	Symptomatic through study period	Endoleak resolution	Persistent T2EL after TAE	30d mortality	Complications	Mean FU after TCE	Sac stabilization during FU	Re - reintervention
Burley et al ²⁰	10/10 (100%)	NR	NR	9/10 (90%)	1/10 (10%)	0%	0/10	1-9.5 mo	10 OF 10	0/10
Heiderman et al ²¹	24/25 (96%) (1/25 fail to access the aneurysm sac)	0/25	0/25	17 of 22	5 of 22	0%	0/25	23.1 mo (22 of 24 patients)	18 of 22	4 of 22 (1 TAE, 3 OSR)
Ryer et al ²²	10/10 100% (access the aneurysm sac and no residual endoleak)	0%	0%	12 of 12	0 of 12	0%	0/12	12.9 +/- 6.7 mo	12 of 12	0 of 12
Overall	44/45 (98%)	0%	0%	38/44 (86%)	6/44 (14%)	0%	0%	-	40/44 (91%)	4/44 (9%)

Figure 10. Outcomes in the TCE group

Discussion

T2ELs are the most common type of endoleak following EVAR. In contrast with type I and type III, T2ELs has a benign course and most the times they are spontaneously resolved. In a systematic review Sidloff et al, found that rupture after EVAR associated with T2EL is rare with the rate being <1%²³. Other authors claim that persistent T2ELs have a significant role in growth of aneurysm sac, can lead in rupture during the follow up period and are associated with increased incidence of adverse outcomes.^{24,25} Current guidelines recommend that T2ELs should be treated when there is sac expansion >10mm during follow up period.²⁶ In our study there was a lower threshold for intervention (>5mm sac expansion in most studies). According to current guidelines practice endovascular approach should be the first treatment of choice. There is a wide variety in the armamentarium of current endovascular practice. However, there are not enough evidence supporting which should be the endovascular treatment of choice. In our analysis, comparing three different endovascular approaches, is shown that technical success remains quite high in every group with 98% in TLE group, 90% in TAE group and 98% in TCE group. Resolution of T2EL was quite low in patients treated with TAE, with a rate of 38%, while in other groups the rate was 83% and 86% for the group A and group C, respectively. In a recent meta-analysis Klaas et al, found that technical success was similarly high as in our study, ranging

from 84% to 100%⁸. The authors outlined that although the technical success was high, one third of the patients failed to completely resolve the endoleak or show signs of sac stabilization or decrease in sac diameter⁸. The 30-day mortality rate was 0% in each group meaning that the safety of each approach is quite acceptable. Minor complications were noted. The rate was 3% for the group A, 7.1% for the group B and 0% for the group C. No further intervention needed to face these complications. Re-intervention rate was 9.1% for the group A, 44% for the group B and 9% for the group C while in every group there were patients that were treated with open conversion during the follow up period. The choice of treatment depends on surgeon's preference but according to our study, translumbar and transcaval embolization seems to be more effective with better mid-term results and lower re-intervention rates.

Conclusions

Translumbar, transarterial and transcaval embolization for persistent type II endoleak present high technical success, low mortality rates and acceptable perioperative complications. Among the three approaches, patients that are treated with transarterial embolization will probably need further intervention in order to achieve sac stabilization and endoleak resolution, compared to the other two endovascular approaches. Open repair could provide always a definitive solution and should be preferred in selected patients only when endovascular means have previously failed.

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