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GUIDELINES

EDITOR'S PICK

Guidelines on prevention, diagnosis and treatment of thoracic and thoracoabdominal aortic pathology: updates from the Italian Society of Vascular and Endovascular Surgery (SICVE)

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ABSTRACT

The aim of these Guidelines was to refresh and enhance the earlier 2015 Italian Guidelines regarding Thoracic and Thoracic - Abdominal Aortic Disease, aligning them with the National Guidelines System (SNLG) to assist all healthcare professionals in adopting the most appropriate treatment approach for this condition. The update utilized the GRADE-SIGN version methodology, adhering to the AGREE checklist for quality reporting. The

initial step involved crafting clinical questions in the PICO (Population, Intervention, Comparison, Outcome) format to base the Recommendations on. Following this, systematic literature reviews were conducted for each PICO question or for related clusters of questions, leading to article selection and evaluation of their methodological quality via qualitative checklists. Subsequently, a Considered Judgment form was completed for each clinical question, assessing the overall evidence to facilitate the conversion from evidence level to recommendation strength and direction. These guidelines outline the best practices for managing thoracic-abdominal aortic disease, with a focus on screening and monitoring. They explore medical treatments and criteria for surgical intervention, including a thorough preoperative analysis of the patient's history and an assessment of surgical risks. Following the determination of surgical necessity, the guidelines compare traditional open surgery with endovascular procedures, paying particular attention to define new recommendations where there were not. Systematic literature reviews were executed for each PICO question. Considered judgments were made through evaluating the evidence level, and the recommendations, direction and strength. The document concludes by outlining protocols for both immediate and prolonged postoperative care. Recent literature has not only validated and refined previous recommendations but also introduced new ones on emerging topics.

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Key words: Guidelines; Abdominal aortic aneurysm; GRADE approach.

Introduction and objectives

Thoracic and thoraco-abdominal aortic disease is undoubtedly one of the greatest vascular medical and surgical challenges due to its complexity, severity, and treatment difficulty. The vascular surgeon maintains a leading role in the management of patients affected by this type of disease, although they must be understood as an active part of a multidisciplinary team including anesthetists, radiologists, and other specialists, established to improve the approach and outcomes. Due to the role held by vascular surgeons, the Italian Society of Vascular and Endovascular Surgery (SICVE) has recognized the urgency of updating, in both methodology and content, the guidelines on thoracic and thoracoabdominal aortic diseases published by the same society in 2015. It is crucial to note that, due to the lack of randomized studies, the scientific evidence level in this chapter's recommendations will seldom be the highest possible, the improved outcomes in managing these diseases have led to the proposal of various approaches with the highest recommendation level, both for a conservative (exclusively medical) approach and in terms of interventional, endovascular and/or open approaches. However, as thoracic and thoracoabdominal aortic disease possesses variants and risks unique to each patient, it will be up to the physician to make the best use of these recommendations and propose, based on the clinical scenario and their experiential knowledge, the most appropriate treatment, optimizing its impact on the patient's life and balancing risks and benefits related to the intervention. To this end, and to facilitate the dissemination of the new recommendations, but above all to make them as shared as possible among the interested parties (stakeholders) and the widest possible fruition nationwide, besides the SICVE, a Scientific Society (SIRM) and a Patient Association (TiToccoToccati) have been involved.

Methodology

This Guideline (GL) constitutes the revision and update of the previous SICVE Guidelines "Treatment of Thoracic and Thoracoabdominal Aortic Diseases"[1] from 2015. The methodology followed in this update is the GRADE-version SIGN,[2] also referring to the methodological indications contained in the Procedures for Submission and Evaluation of Guidelines for publication in the SNLG - Operational Manual[3] and the Methodological Manual for the production of clinical practice guidelines,[4] prepared by the National Centre for Clinical Excellence, Quality and Safety of Care (CNEC). The guideline was developed fol-

lowing the indications of the AGREE quality of reporting checklist[5] and, once completed, was evaluated using the AGREE II tool.[6-8]

Composition of the working group

The working group was composed as follows: the GL Coordinator; the Technical Scientific Committee (CTS), composed of representatives of each participating Scientific Society; the Expert Panel – Authors, composed of a multidisciplinary group of clinician experts in the subjects addressed in this GL; the Methodological Group, with a Referent, composed of experts in systematic literature review and quality assessment of evidence; the Scientific and Technical-Organizational Secretariat. In particular, the multidisciplinary expert panel includes the following specialties: vascular surgery and medical radiology. Besides SICVE, the proposing society, the Italian Society of Medical Radiology (SIRM) has been involved. To gather patients' views and preferences, the "TiToccoToccati" Vascular Patient Association was also involved in the Guideline work through the submission to "expert patients" of a General Information on Thoracic and Thoracoabdominal Aortic Disease and a short questionnaire on the acceptability by the patient of the indications proposed by the Guidelines.

Editorial independence

No external funding was received for the drafting of this Guideline. All the authors of the Guideline filled out the conflict-of-interest declaration form adapted from the Methodological Manual to produce clinical practice guidelines of the SNLG. The declarations are available on the SICVE website (https://sicve.it/). All authors have declared that they have no financial, professional or other conflicts of interest related to the topics addressed in this Guideline. In cases where an author declared relevant conflicts of interest, it was foreseen to apply one or more of the following measures for managing the conflict of interest: 1) full participation in the work, with public disclosure of the interest; 2) partial exclusion from the work (*e.g.*, exclusion from the part of the meeting or work related to the declared interest and the related decision-making process); 3) total exclusion (limitation to participation in any part of the meeting or process).

Formulation of clinical questions

The first step was to formulate clinical questions using the PICO model (Population, Intervention, Comparator, Outcome), which served as the basis for the recommendations. The PICO questions were formulated collaboratively by the multidisciplinary panel of experts.

Systematic literature review

Subsequently, systematic literature reviews were conducted for each PICO question or for homogeneous groups of questions. Searches were conducted in PubMed, the Cochrane Database of Systematic Reviews (CDSR), and the Cochrane Central Register of Controlled Trials (CENTRAL). Searches were initiated from January 2016 onwards, updating the searches of the previous SICVE guidelines that concluded in December 2015. The complete list of search strategies, along with PRISMA Flow Diagrams describing the literature selection process, were compiled.

Process of literature selection and critical evaluation

The literature selection was performed independently by pairs of members of the Methodological Group for each clinical question or topic. The inclusion and exclusion criteria for selection were established *a priori* and were based on the PICO elements and study designs. The first selection was based on the reading of titles and abstracts, while the second selection concerned the analysis of full-text articles. Any discrepancies in evaluation between the two authors were resolved through discussion. Once the final included articles were defined, the authors independently assessed the methodological quality of each article using specific qualitative checklists provided by the GRADE-version SIGN methodology - Appendix 2. These checklists were used to assess the quality of systematic reviews/meta-analyses, randomized clinical trials (RCTs), cohort studies, case-control studies, and diagnostic accuracy studies. The quality of case series was evaluated using the checklist of the Institute of Health Economics (IHE), while the quality of case reports was assessed using the Case Reports Guidelines (CARE) checklist. In cases where other international guidelines were used as a basis of evidence, these were pre-evaluated using the AGREE II checklist, considering a minimum acceptability threshold of a total score of 60% (dimensions 3 and 6: minimum 50%), as indicated in the CNEC Operational Manual. The levels of evidence attributable to the different study designs evaluated through the checklists are shown in Table I. After evaluating the methodological quality of each included article for each PICO question, Evidence Tables were developed describing the main characteristics of these stud-

Table I.—*Levels of evidence.*

Levels	Description
1++	High-quality meta-analyses and systematic reviews of randomized clinical trials with very low risk of bias; single randomized clinical trials with a very low risk of bias
1+	Well-conducted meta-analyses and systematic reviews of randomized clinical trials with low risk of bias; single randomized clinical trials with low risk of bias
1-	Meta-analyses and systematic reviews of randomized clinical trials with high risk of bias; single randomized clinical trials with high risk of bias
2++	High-quality systematic reviews of case-control or cohort studies; high-quality case-control or cohort studies with very low risk of confounding or bias and a high probability that the relationship is causal
2+	Well-conducted case-control or cohort studies with low risk of confounding or bias and a moderate probability that the relationship is causal
2-	Case-control or cohort studies with high risk of confounding or bias and a significant risk that the relationship is not causal
3	Non-analytical studies, *e.g.*, case reports and/or case series
4	Expert opinion

Table II.—*Grading of recommendations.*

Expert opinion	Recommendation
Undesirable effects clearly outweigh desirable effects	Strong recommendation against
Undesirable effects probably outweigh desirable effects	Weak recommendation against
The balance between undesirable and desirable effects is delicate or unclear	Recommendation for research and limited use within trials
Desirable effects probably outweigh adverse effects	Weak recommendation in favor
Desirable effects clearly outweigh adverse effects	Strong recommendation in favor
Best practice recommended based on the clinical experience of the guideline panel	Good practice point (GPP)

ies: study design (in the case of systematic reviews/meta-analyses, the number and design of the included studies were indicated), level of evidence, characteristics of the population (number of patients, pathology, age, gender), intervention(s), comparator(s), outcomes, effect measures for each outcome with their confidence intervals and P values, any comments regarding methodological limitations and the generalizability of the results concerning the PICO question.

From evidence to recommendations

The methodology used requires that, once the evaluation of the methodological quality of the included articles is completed, the authors – panel of experts proceed with completing the Considered Judgement form for each clinical question. This form consists of two sections, A and B. The considered judgement takes into account the characteristics of the body of evidence available (part A of the form), answering the following questions: 1) how reliable are the studies contributing to the body of evidence?; 2) are the study results consistent?; 3) are the studies relevant to the target population?; 4) are we sure we have all available evidence (assessment of potential publication bias)? Subsequently, part B of the form is completed, which assists the authors in translating evidence level into the direction and strength of recommendations. The topics addressed in part B are: 1) balance of benefits and harms; 2) acceptability of the intervention by patients/families/caregivers; 3) applicability/feasibility of the intervention in the context where the guideline will be used.

Formulation of recommendations

Once all the considered judgements were completed, the authors presented and discussed them during two plenary meetings held via videoconference on 01/02/2022 and 08/02/2022. Following the presentation of the considered judgements and recommendations, an informal consensus process on the strength and direction of the recommendations took place. Recommendations are formulated on two levels: strong and weak. Typically, high-quality evidence derived from well-conducted studies leads to a strong recommendation, but it may happen that, considering the differences between the population described in the studies and the target population, the acceptability by patients, and the applicability of the interventions, the recommendation is indicated as "weak." Conversely, there may be circumstances where the evidence is technically modest, but there are no negative or controversial aspects of the treatment, and the clinical importance of the topic is such as to still formulate a strong recommendation. Good Practice Points

(GPP) support LG users in decision-making, offering "indications" from the panel of experts based on common clinical experience even in the absence of evidence or lack of sufficient evidence to support them, on issues deemed relevant to clinical practice. Below is a summary schema of the recommendation grades (Table II).

External review

The final version of the guideline was submitted for external review to independent experts on the topics addressed and representatives of patient associations, to receive their comments and proposals for modifications or additions. Reviewers were also asked to indicate any facilitating factors and obstacles to the application of the guideline, as well as suggestions and tools for implementation. The comments received from the reviewers were considered by the panel of authors, who responded to the comments and decided which modifications to make to the text based on these comments.

Guideline update procedure

The guideline is expected to be updated every three years from the date of publication on the SNLG platform. The methodology followed in the update will be the same as used in the present version, or a similar methodology based on the GRADE approach. Literature searches will start from the date on which the current searches were conducted.

Considerations regarding the applicability of recommendations

The panel of authors expressed considerations regarding the applicability of the interventions subject to recommendations in the specific context where the guideline will be applied, in a specific section of the Considered Judgement form. In particular, the authors considered: feasibility of the interventions in the entire national context or only in specialized centers; required expertise of healthcare providers; financial resources, healthcare personnel or other resources necessary for the application of the recommendations. Further considerations regarding the applicability of the recommendations and suggestions for improving their implementation came from external reviewers. The considerations regarding applicability were taken into account by the panel of experts in the formulation of the recommendations.

Dissemination and monitoring

Once the guideline is deemed suitable for publication by the CNEC, it will be published on the SNLG website and the websites of the participating scientific societies; it will also be presented at major conferences on vascular diseases. Subsequently, the guideline will be translated and submitted for publication in a peer-reviewed international journal. For monitoring the implementation of the guideline, it is planned to conduct an annual periodic audit involving a heterogeneous group of healthcare professionals from different care contexts to verify adherence to the recommendations contained in this guideline, also using specific clinical indicators, and to gather information on any factors hindering or facilitating the implementation of the guideline.

Reporting

The guideline was developed following the indications of the AGREE quality of reporting checklist.

Main evidences and assessments from the literature

Dissections (A, B, non-A/non-B), intramural hematoma, penetrating ulcers: definition, classification, medical and surgical management

The diagnosis and the treatment of acute aortic syndromes has to be immediate to have the best results. Mussa *et al.*[9] in a systematic review shows that CT angiography has a sensitivity and specificity of 100% on the primary diagnosis and highlight the crucial role of blood and instrumental examinations for diagnostic framing and patient management. Regarding the multidisciplinary approach in managing patients with acute type A dissection, there are no studies that analyze this kind of approach. Settepani *et al.*[10] analyzes the comparison between ascending aorta repair alone and more extensive repair involving the arch and descending thoracic aorta.

Regarding medical therapy, Masaki *et al.*[11] shows that adding pitavastatin therapy might play a role in counteracting aortic arch dilation in patients with acute type B dissection. According to Osgood *et al.*,[12] systematic renal Doppler ultrasound (DUS) could reduce the progression to renal damage, identifying patients with renal malperfusion who candidates for surgical intervention may thus be. Adas *et al.*[13] focuses on the importance of adequate blood pressure control. Although it does not distinguish between complicated and uncomplicated cases in the analysis, it

suggests that a sudden and significant reduction in blood pressure could lead to cerebral damage related to hypoperfusion episodes. Suzuki *et al.*[14] extrapolated data from the IRAD (International Registry of Aortic Dissection) multicenter registry. Multivariate analyses showed, in the type B dissection subgroup, that calcium channel blockers significantly reduce the risk of mortality (HR 0.554, 95% CI 0.348-0.880, P=0.012), while the use of beta-blockers and ACE inhibitors has insignificant role in patient survival.

The available data[15-18] that analyzed the comparison between open surgical treatment and endovascular treatment, indicate a short-term benefit for patients undergoing TEVAR, without a clear medium to long-term benefit.

The studies[17, 19, 20] concern the target population and are generally consistent, demonstrating a greater tendency for aortic dilation with less thrombosis/remodeling of the false lumen of the dissection in cases treated with medical therapy alone. However, there is no unanimous evidence of the superiority of endovascular treatment over medical therapy alone. The benefits of endovascular treatment are more evident in the long term, due to reduced dissection progression, increased thrombosis/remodeling of the false lumen, and fewer interventions.

Mussa *et al.*[9] report that, although aorta-related mortality was higher in the first 12 months in the TEVAR-treated group compared to medical therapy alone (7.5 *vs.* 3.0%), TEVAR is associated with reduced disease progression at 5 years (4.1% *vs.* 19.3%; P=0.04) without reducing overall mortality (11.1% *vs.* 19.3%, P=0.13).

In case of patients with acute non-A non-B dissection based on the reviewed literature,[21-24] it can be concluded that NANBAD tends to have a complicated onset. However, there is no unanimous agreement on the indications and various types of interventions. Therefore, considering the IRAD data, it is believed that treatment should be personalized based on the anatomical characteristics of the dissection, specifically based on its proximal or distal extension.

In case of uncomplicated Intramural Hematomas medical therapy is considered the first treatment. Moral *et al.*[25] focus on identifying dissection progression criteria *via* CT angiography: they recommend systematic follow-up even in cases where there are tiny intimal disruptions (TIDs) with a diameter of less than 3 mm, as approximately 14% may increase in size within six months, worsening the prognosis. As for the complicated cases there is no direct comparison between surgical and endovascular therapy, Li *et al.*[26] report a reduction in aorta-related mortality in patients undergoing endovascular intervention (OR=0.239, 95% CI 0.075-0.758, P=0.015), with a reduction in cases of disease progression (OR=0.248, 95% CI 0.085-0.725, P=0.011).

Regarding penetrating aortic ulcers, if uncomplicated therapy may be the first choice.[27] In complicated cases, the benefit of the intervention lies in the correction of the ulcer with acceptable morbidity and mortality rates, preventing progression to intramural hematoma, dissection, aneurysm, or aortic rupture.[27-30]

Imaging techniques

Angio-CT is a well-established imaging technique for studying thoracic and thoraco-abdominal aortic pathology, both for preoperative evaluations and for postoperative control and follow-up, despite involving exposure to ionizing radiation and iodinated contrast medium.[31-34] We also identified studies[35-41] that compare angio-MRI and angio-CT but also between MRI with and without contrast (or other contrast media) and different protocols to improve image quality in this region. However, it is not always available in every center and its use is limited in emergency conditions. The contraindications for MRI in subjects with prosthetic components or ferromagnetic implanted devices and in claustrophobic patients are well known. Additionally, the risks associated with using paramagnetic contrast medium (gadolinium) are linked to nephrogenic systemic fibrosis in patients with severe renal insufficiency.

As a matter of fact, we identified studies that analyze different aspects of a technology that has already become part of the daily portfolio of vascular surgeons, having become essential to precisely identify vascular anatomy, make diagnoses, accurately plan treatment, and evaluate the evolution of a disease or the outcome of a treatment over time. Study highlighted that using 3D reconstruction software for creating curved MPR allows for less intermodal and intra-observer variability during preoperative planning compared to conventional MPR measurements (P<0.05). Given the wide variety of available software, it is a technology that can be available at any center and poses no risk or additional cost to the patient.[42-44]

Although CT angiography remains the method of choice for accurate diagnosis and preoperative planning of TEVAR, in cases of hemodynamic instability and in angulated aortic segments, it may underestimate the true aortic diameters, potentially leading to the downsizing of the endograft. In this context, IVUS can serve as an adjunctive tool, providing real-time assessment of aortic diameters and endograft landing zones, particularly in angulated

anatomies. However, its long-term benefit still requires validation through multicenter, randomized studies that also consider protocols for volume resuscitation and the hemodynamic parameters of patients with hemodynamic instability. The main limitations of IVUS are related to operator training, material costs, and its availability in advanced radiological suites and/or hybrid theatres.[45-51]

The use of intraoperative fusion imaging allows for the reduction of exposure to ionizing radiation and use of contrast medium in patients undergoing endovascular treatment for thoracic and thoraco-abdominal aortic diseases. The studies are relevant to the target population, and considering the non-invasiveness relative to the obtainable benefits, this technology has a significant impact on the quality of treatment. This technology requires adequate training and is limited by its availability and integration into advanced radiological suites (*e.g.*, hybrid rooms), allowing for its full potential to be exploited.[52-56]

As for the CBCT. Tenorio ER[54, 57] demonstrates the ability to diagnose and potentially treat any intra-procedural complications or defects makes it a powerful tool for complex aortic treatments with fenestrated or branched stent-grafts. Its limitation is availability within advanced radiological suites (*e.g.*, hybrid rooms).

Pre-procedural and perioperative management in acute thoracic and thoraco-abdominal aortic diseases

In literature, there is general agreement on maintaining mean arterial pressure above a certain target (in most experiences >80 mmHg) in both endovascular and surgical treatment of patients with thoracic and thoraco-abdominal extension disease.[58-62] These data are limited to expert opinion and mainly relate to patients treated for elective aneurysmal disease. There is a complete lack of data on patients treated for acute disease.

Available evidence on the utility of moderate hypothermia during aortic treatment in thoracic or thoraco-abdominal localization is scarce and limited to patients treated electively, particularly via traditional surgical approach. There is agreement on the utility of moderate hypothermia in the surgical treatment of the descending thoracic aorta, while evidence is lacking for its utility during endovascular treatment of the same region.[60, 63]

Regarding renal protection during traditional or endovascular surgery for thoracic or thoraco-abdominal aortic disease report the results of patients treated electively mostly for thoraco-abdominal aneurysmal disease. Available literature data are insufficient to formulate recommendations for patients treated for acute disease.[64-68]

Ruptured thoracic and thoraco-abdominal aneurysm: open/endo management

All studies[60, 68-74] agree that the endovascular approach (TEVAR) is the first-line treatment for patients presenting with ruptured descending thoracic aortic aneurysm due to better short-term survival outcomes and less immediate impact on the patient. For most authors, traditional surgical treatment for this condition should be limited to patients with anatomy unfavorable for endovascular treatment. Traditional surgical approach is the first-choice treatment[75, 76] for patients presenting with ruptured thoraco-abdominal aortic aneurysm despite some studies reporting lower rates of pulmonary and renal complications in patients treated endovascularly. Several authors describe endovascular treatment as a life-saving bridge therapy applicable in hemodynamically stable patients[69, 77-83] in centers where definitive surgical treatment is not feasible, pending a definitive surgical treatment. The main limitation of endovascular method is its proven poor durability over time, currently unable to guarantee satisfactory medium to long-term outcomes due to recurrence or disease progression. Literature on this topic is scarce both numerically and in terms of evidence level, almost entirely from expert opinions. Given the nature of the topic, randomized clinical trials seem currently unfeasible.

The literature[69, 84-86] support early placement of thoracic drainage in case of hemothorax secondary to ruptured thoracic aneurysm as this procedure can reduce pulmonary complications and increase patient survival. There are no recent studies on hemothorax drainage in case of ruptured thoraco-abdominal aneurysm, but it seems intuitive that in this population as well, in case of hemothorax secondary to aortic rupture, early drainage (within the first 24 hours) may improve clinical outcome. Further evidence will be needed to increase the level of this recommendation and identify the most appropriate timing for pleural drainage placement.

Descending thoracic aortic aneurysms and thoracic aortic trauma: medical and surgical management

Primarily, all studies have highlighted a greater benefit of endovascular treatment compared to open surgery in treating descending thoracic aortic aneurysms, especially in terms of perioperative morbidity and mortality.[70, 87-91] The limitation remains the lack of randomized clinical trials comparing endovascular *vs.* open treatment, and of course the long-term data.

All meta-analyses, systematic reviews, and cohort studies agree that in patients with thoracic aortic trauma, TE-

VAR is superior to open surgery in terms of peri-procedural mortality.[92-99]

Descending thoraco-abdominal aortic aneurysms: medical and surgical management, and neurological implications

The indications for the treatment of patients affected by TAAA depends on many factors.

Medical therapy is indicated for patients who have not yet reached the diameters requiring treatment indication. Prospects for conservative treatment in TAAA are disappointing. The same three single-center studies showed that in patients with thoraco-abdominal aortic aneurysm, open surgical treatment might be indicated when the diameter is 55 cm.[100-102] In cases of Marfan syndrome and Ehlers-Danlos Syndrome, the indication is lowered to a threshold diameter of 5 cm, while in Loeys-Dietz Syndrome, repair is advised at an aortic diameter of only 4.2 cm due to the particularly aggressive nature of this aortopathy.[103] Studies evaluating open treatment agree in showing mortality linked to the extent of aneurysmal pathology (>Crawford types II and III). Despite improvements in surgical technique, the treatment of thoraco-abdominal aneurysms remains burdened by considerable morbidity and mortality.[104] Despite efforts to prevent some of the most common complications such as spinal cord ischemia, respiratory complications, permanent postoperative dialysis, stroke, and cardiac events, these events continue to influence the procedure's outcome. To reduce renal ischemic injury during surgical treatment, the perfusion with crystalloids reduces the incidence of postoperative renal insufficiency.[105-107] Additionally, to reduce both renal and spinal hypoperfusion, the use of LHB might be considerate, although not all studies show a reduction in postoperative renal damage.[64, 68, 108, 109] A systematic review and a single-center observational study report lower mortality in high-volume centers and patients aged 50 years or younger.[64, 68] A prospective study has evaluated the quality of life (QOL) from the diagnosis of thoraco-abdominal aneurysm to the postoperative period. This study confirmed a relatively poor baseline QOL, attributed by the authors to associated comorbidities and the anxiety associated with TAAA diagnosis and impending surgery. Six to twelve months post-operation, patients returned to pre-operative conditions.[110] A comparative study comparing QOL in patients treated with endovascular procedures for pararenal and thoraco-abdominal aneurysms shows that treatment with F-BEVAR was associated with a significant decline in Physical Component Scores (PCSs) in both groups, which improved after two months and returned to baseline values at 12 months in PAA patients but not in TAAA patients.[111] The literature does not report comparisons of QOL in TAAA patients treated with open and endovascular procedures. A meta-analysis shows that in high-risk surgical patients, endovascular treatment with branched/fenestrated stent-grafts or alternative techniques, if anatomically feasible, should be considered as an alternative treatment.[112, 113] Two systematic reviews show that endovascular treatment is still burdened by a significant risk of perioperative mortality and complications. When evaluating perioperative mortality and complications, it must be considered that patients treated with endovascular procedures include older patients with more comorbidities. Endovascular treatment is associated with higher SCI rates but similar rates of permanent paraplegia. Studies evaluating surgical treatment have higher rates of postoperative dialysis, but similar rates of permanent dialysis compared to endovascular treatment. Perioperative mortality rates are similar between the two procedures.[113, 114] A single-center study on 38 patients with TAAA treated with snorkel/sandwich endografts (21 celiac, 28 superior mesenteric arteries, 58 renal arteries) and 32 patients with juxtarenal (JRA)/suprarenal (SRA) aneurysm treated with fenestrated stent-grafts showed that these methods have acceptable and comparable mortality and patency rates in the endovascular treatment of JRA, SRA, and TAAA.[115]

A meta-analysis reports that the use of MEP (motor evoked potentials) and SEPS (somato-sensory evoked potentials) can be used for intraoperative monitoring to quickly verify and apply maneuvers to increase spinal cord perfusion. A single-center observational study shows that MEP and SEPS can also be used in endovascular treatment. Controversial opinions are reported in two meta-analyses regarding the use of cerebrospinal fluid drainage (CSFD). A meta-analysis shows that revascularization of the left subclavian artery (LSA) is associated with a reduction in the risks of cerebrovascular accident, spinal cord ischemia, and left upper limb ischemia in endovascular treatment of the thoracic aorta with LSA coverage. For staged treatment of endovascular procedures, five single-center studies report a reduction in the incidence of SCI regardless of the staged technique used.

Aorto-esophageal and aorto-bronchial fistulas

In case of graft infection, a systematic literature review has shown that surgical treatment with graft explant appears to be the preferable choice in patients suitable for surgical treatment. A lower one-year mortality rate was ob-

served in patients undergoing graft explant. In a systematic literature review, the incidence and early onset of aorto-esophageal fistula are more evident in endovascular treatment. A meta-analysis has shown an increased one-year mortality in patients with surgical graft infection compared to endograft infection (aggregated OR=3.6; 95% CI, 0.9-14.7; P=0.073). Surgical management with graft explant was associated with lower one-year mortality compared to conservative treatment (aggregated OR=0.3; 95% CI, 0.1-1.0; P=0.056). In a systematic review and meta-analysis involving 96 patients with infected thoracic endografts, 41 had EG explant, and 55 had EG preservation, with mortality rates of 37% *vs*. 42%, respectively, while late mortality was 46% *vs*. 82% for EG explant and EG preservation, respectively. In a meta-analysis, one-year mortality was 37% (15/41) for total surgical graft explant *vs*. 85% (17/20) for partial or total graft preservation. Two single-center observational studies report that in patients with aorto-esophageal and aorto-bronchial fistula, the risk of recurrence in terms of graft infections and fistulas is high. Two single-center observational studies show good results using allografts in terms of infection resistance. One of the most serious complications associated with graft or endograft infection is bleeding; in these cases, endovascular bridge treatment is possible.

Aortic arch aneurysms and chronic dissections: medical and surgical management

In patients with aortic arch aneurysms the literature data[116-133] shows that the benefits of intervention include protection against potential rupture, dissection, or cerebral embolization. Treatment is indicated for aortic arch aneurysms when the vessel diameter reaches 5.5 cm, while in the presence of connective tissue diseases and/or bicuspid aortic valve, it is indicated at 5 cm. Hybrid and endovascular techniques have shown promising morbidity/mortality results in the short and medium term, reducing or eliminating the need for cardiopulmonary bypass and circulatory arrest and limiting clamping time. Hybrid or endovascular treatment, though associated with a higher rate of reinterventions compared to open therapy, represents the first choice for "unfit for surgery" patients (about 40% of the target population) due to the lower percentage of immediate perioperative complications. Surgical treatment continues to be considered the standard for low-risk patients due to more favorable long-term results compared to endovascular or hybrid techniques.

The studies reviewed agree that medical treatment is the first choice[103, 134-137] for aneurysms >4.5 cm and suggest closer follow-up (CT every 6 months) in cases of rapid growth, greater than 5 mm/year. The indication for surgical treatment is not conditioned by the growth rate and is still set at reaching the diameter of 5.5 cm. Monitoring is primarily performed with CT, reserving MRI and echocardiography for selected cases. Performing semi-annual/annual CT scans in patients with aneurysms growing 5-5.5 mm/year is justified until the diameters considered cut-offs for treatment are reached; in aneurysms considered low risk (diameter ≤4.5 cm) with slow growth (<3 mm/year), annual CT scans increase exposure to ionizing radiation and are therefore not justified. Authors agree on a surgical approach for aneurysms <5.5 cm in patients with connective tissue diseases due to the higher risk of rupture associated with a higher growth rate.

Open surgical intervention is indicated in patients under 75 years old at low surgical risk because it guarantees 10-year survival rates up to 74%. Hybrid and endovascular therapies achieve immediate results comparable to open surgery in patients considered "unfit for surgery" due to comorbidities or age over 75 years.[116, 138-147]

Regarding aortic chronic dissection the most appropriate medical therapy is the administration of multiple drugs targeting not only blood pressure control but also heart rate reduction.[148, 149] Medical therapy is a valid option in treating patients with chronic dissection without significant risk factors within the first two years from disease onset. A precise timing for treatment has not been identified yet; however, in the presence of anatomical characteristics considered negative prognostic factors for unfavorable aortic events (vessel diameter greater than 50-55 mm, false lumen patency, entry tear >10 mm), it would be appropriate to direct patients to surgical therapy (open or endovascular).[17, 150-157] Endovascular treatment for chronic thoracic aortic dissection offers advantages in terms of perioperative mortality and complications; however, it is burdened by a higher number of reinterventions compared to open treatment, likely also due to the disease's characteristics. Open treatment remains the gold standard for treating patients with chronic dissection and connective tissue diseases at low surgical risk, although endovascular treatment is increasingly considered a valid alternative in high surgical risk patients.[150, 151, 153, 158-163]

Aortic coarctation, aortic arch and descending thoracic aorta atheroma, aortic tumors, and follow-up

The literature provides limited evidence on the best approach for studying aortic coarctation. Lacking direct comparison between various methods and performed in highly

specialized centers, they are characterized by high risk of bias. Static morphological imaging (CT, MRI) easily diagnoses stenosis at the aorta level but does not allow the evaluation of hemodynamic parameters. In a cohort study, Cordero *et al.*[164] included 50 pre and post-transcatheter treated patients, studying flow changes with Doppler TEE, finding a good correlation between systolic and diastolic parameters and the severity of coarctation. Additionally, aortic stiffness and its impact on ventricular function were also evaluated by Voges *et al.*[165] using cardiac magnetic resonance (CMR). The authors conclude that CMR offers important advantages, allowing cardiac measurements and studying bioelastic changes in the aortic wall. Given the indication to treat all patients with coarctation and simultaneous arterial hypertension, radiological imaging is crucial in the preoperative phase to stratify risk and predict possible complications even in the medium and long term. Bruse *et al.*[166] reconstructed the 3D shape of the treated aorta using CMR sequences, subjecting them to a statistical approach (SSM – Statistical Shape Modelling), finding a correlation between some types of arch and ejection fraction, end-diastolic volume, and ventricular mass. In another CMR study, Quail *et al.*[167] found a correlation between residual aortic diameters and pathological reflected pressure waves. Kelm *et al.*[168] used CMR to derive hemodynamic parameters, particularly the Windkessel function, important for informing potential patient-specific fluid dynamic models.

As for the surgical treatment of aortic coarctation Rajbanshi *et al.*[169] report good medium to long-term results, mainly with open treatment using tubular graft interposition. Cho, Ge, and Delmo reported good results using extra-anatomic bypass techniques (subclavian-descending aorta and ascending aorta-abdominal aorta) with a low incidence of short and long-term complications.[170-172] Caruana *et al.* compared 59 patients primarily treated with open surgery and subjected to long-term follow-up (mean 26 years, range 1-45), comparing them with age and sex-matched controls.[173] The average post-intervention survival was 40 years, with a reintervention-free rate of 77%. However, increased cardiovascular mortality was observed in operated patients compared to the general population (11.9% *vs*. 1.4%) with a reduced life expectancy (68 *vs*. 86 years). Bassiri *et al.* analyzed a cohort of 133 endovascular coarctoplasties, mostly with Cheatham-platinum covered stents (CCPS).[174] No correlation was found between aorta morphology and acute complications, while restenosis incidence was correlated with a plastic length >40 mm and aortic diameter.

In patients with aortic atheroma the risk of complications correlates with the degree of atheroma, and for this reason, it is important to predict which atheromas may progress over time.[175] Multivariate analysis showed a higher degree of baseline atheroma as a predictor of progression associated with smoking habits and less use of anticoagulants. Although an optimal therapy cannot be indicated, the authors conclude on the usefulness of modifying cardiovascular risk factors such as smoking habits and close follow-up with TEE of high-grade plaques, suggesting a probable beneficial effect of anticoagulant therapy on progression. The comparison between anticoagulant and antiplatelet therapy was explored in a subpopulation of NAVIGATE ESUS trial participants, as reported by Ntaios *et al.*[176]

Mural thrombus can result in peripheral embolic complications in case of fragmentation. Meyermann *et al.* conducted a narrative literature review over 15 years, including 74 patients, of which 82.4% were diagnosed post-peripheral embolism (N.=42 lower limbs, N.=24 visceral, N.=8 other).[177] Patients had an equal probability of receiving medical, open surgical, or endovascular treatment. Nine patients (34.6%) treated with medical therapy had thrombus persistence *vs*. 31.6% of surgically treated patients. In the endovascular group, mural thrombus was successfully excluded in 93.1% of patients. Borghese *et al.* presented a cohort study of nine patients with mural thrombus undergoing anticoagulation and early open treatment.[178] No mortality was detected with a median follow-up, but a significant proportion of patients (55.5%) required reintervention for thrombus persistence. Weiss *et al.* presented a series of 10 patients with floating thrombus of the arch.[179] One patient died of supra-aortic trunk occlusion, and three were treated with anticoagulation.

In patients with aortic tumor all cases should be addressed by a multidisciplinary team.[180] There is no unanimous consensus on the best therapeutic scheme. The most proposed therapy is surgical treatment with tumor resection and graft replacement.[181] Adjuvant chemotherapy regimens commonly used include taxanes and anthracyclines.[180] In a meta-analysis conducted by Vacirca *et al.*, 223 published cases of aortic tumor are analyzed. The author reports that combined surgical therapy with chemotherapy and radiotherapy has a better impact on survival (12 [range 8-24] months), significantly greater than surgical treatment alone (7 [range 2-16] months) and no treatment (2 [range 0.5-15] months).[181] Endovascular therapy is proposed as palliative care in cases of aortic rupture or peripheral embolization prevention.[60, 182] National Comprehensive Cancer Network guidelines suggest consider-

ing adjuvant radiotherapy for sarcomas of large vessels. Currently, no neoadjuvant chemoradiotherapy treatment schemes are proposed. Given the scarcity of published literature data, fundamentally related to the rarity of the pathology, no recommendation can be made.

PICO and recommendations

PICO 2.1

In patients with suspected acute aortic syndrome (P), is it indicated to perform a CT angiography (I) as the first choice compared to other imaging techniques (C) for diagnosis (O)?

Recommendation

In patients with suspected acute aortic syndrome, CT angiography is suggested for the diagnosis as the first choice compared to other imaging techniques (Good Practice Point - GPP).

PICO 2.2

In patients with acute type A dissection (P), can a multidisciplinary approach (I) be advantageous compared to a single-specialty evaluation (C) to improve outcomes (O)?

Recommendation

In patients with acute type A dissection, a multidisciplinary approach is suggested for patient management and to improve outcomes (GPP).

PICO 2.3

In patients with acute type B dissection (complicated or uncomplicated) (P), is it indicated to perform blood and instrumental examinations with monitoring of vital parameters in intensive care (I) to identify possible complications from organ damage and improve outcomes (O), compared to clinical monitoring alone (C) in a non-intensive care setting?

Recommendations

1. In patients with acute type B dissection (complicated or uncomplicated), achieving adequate control of systolic blood pressure, heart rate, and pain symptoms through the use of antihypertensive/negative chronotropic drugs (particularly intravenous/oral calcium channel blockers) and analgesics is indicated to reduce complications and improve outcomes (strong recommendation in favor, level of evidence 1-).

2. In patients with acute type B dissection (complicated or uncomplicated), performing blood and instrumental examinations to study possible organ damage complications (visceral, renal, lower limb, neurological) is indicated (strong recommendation in favor, level of evidence 1-).

3. In patients with acute type B dissection (complicated or uncomplicated), intensive monitoring is suggested to improve outcomes (GPP).

PICO 2.4

In patients with complicated acute type B dissection (P), is endovascular surgical treatment (I) indicated compared to open/hybrid surgical treatment or medical therapy alone (C) to resolve complications and improve survival rate (O)?

Recommendation

In patients with complicated acute type B dissection, endovascular surgical approach via TEVAR for coverage of the proximal entry tear is indicated over open/hybrid surgery or medical therapy alone to treat complications and improve survival rates (Strong recommendation in favor, level of evidence 2++).

PICO 2.5

In patients with uncomplicated acute type B dissection (P), could an endovascular surgical approach (I), compared to conservative medical therapy alone (C), be indicated to prevent complications and improve medium and long-term survival (O)?

Recommendation

In patients with uncomplicated acute type B dissection with "appropriate anatomy" endovascular therapy may be preferred over conservative medical therapy alone to favor aortic remodeling and improve medium and long-term survival (weak recommendation in favor, level of evidence 1+).

PICO 2.6

In patients with acute non-A non-B dissection (P), is surgical treatment (I) indicated compared to conservative therapy alone (C) to prevent or treat complications and improve survival rates (O)?

Recommendations

1. In patients with acute non-A non-B dissection with retrograde extension and involvement of the ascending aorta, an open surgical treatment is indicated to prevent or treat complications and improve survival rates (strong recommendation in favor, level of evidence 2++).

2. In patients with acute non-A non-B dissection with anterograde extension and involvement of the descending thoracic aorta, a hybrid endovascular treatment or medical therapy may be indicated to prevent or treat complications and improve survival rates (weak recommendation in favor, level of evidence 2++).

PICO 2.7

In patients with acute non-A non-B dissection (P), is a multidisciplinary approach (I) considered appropriate compared to a single-specialty approach (C) to improve outcomes (O)?

Recommendation

In patients with acute non-A non-B dissection, a multidisciplinary approach is suggested to improve patient outcomes (GPP).

PICO 2.8

In patients with uncomplicated intramural hematoma (P), is medical therapy (I) indicated compared to a surgical approach (endovascular, open, hybrid) (C) to prevent complications and improve survival (O)?

Recommendations

1. In patients with uncomplicated intramural hematoma, medical therapy may be indicated compared to a surgical approach (endovascular, open surgical, hybrid) to prevent complications and improve survival (weak recommendation in favor, level of evidence 2++).
2. In patients with uncomplicated intramural hematoma, serial follow-up with CT angiography is indicated to monitor disease progression, prevent complications, and improve survival (strong recommendation in favor, level of evidence 2++).

PICO 2.9

In patients with complicated intramural hematoma (P), is open or endovascular surgical approach (I) indicated compared to medical therapy alone (C) to treat complications and improve survival rates (O)?

Recommendation

In patients with complicated intramural hematoma, an open or endovascular surgical approach is indicated over medical therapy alone to improve outcomes (strong recommendation in favor, level of evidence 2++).

PICO 2.10

In patients with uncomplicated penetrating aortic ulcer (P), is medical therapy (I) indicated compared to a surgical approach (endovascular, open, hybrid) (C) to prevent complications and improve survival rates (O)?

Recommendations

1. In patients with small, uncomplicated penetrating aortic ulcer, a medical therapy approach may be indicated over an interventional approach (endovascular, open surgical, or hybrid) to prevent disease progression (weak recommendation in favor, level of evidence 2+).
2. In patients with uncomplicated penetrating aortic ulcer, serial follow-up with CT angiography is indicated to monitor disease progression, prevent complications, and improve survival (Strong recommendation in favor, level of evidence 2+).

PICO 2.11

In patients with complicated penetrating aortic ulcer (P), is a surgical approach (endovascular, open, or hybrid) (I) indicated compared to medical therapy alone (C) to prevent complications and improve survival (O)?

Recommendation

In patients with complicated or large penetrating aortic ulcer, a surgical approach (endovascular therapy, open surgical, or hybrid) is indicated over medical therapy alone to prevent complications and improve survival (strong recommendation in favor, level of evidence 2+).

PICO 3.1

In patients with thoracic and thoraco-abdominal aortic diseases (P), should computed tomography with contrast medium (angio-CT or CTA) (I) be used for accurate diagnosis and precise preoperative planning (O)?

Recommendation

The use of angio-CT is indicated for diagnosis, preoperative planning, and postoperative control of thoracic and thoraco-abdominal aortic diseases (strong recommendation in favor, level of evidence 2+).

PICO 3.2

In patients with thoracic and thoraco-abdominal aortic diseases (P), should magnetic resonance imaging with contrast medium (angio-MRI) (I) be used instead of angio-CT (C) to achieve greater diagnostic accuracy (O)?

Recommendation

The use of angio-MRI may be indicated for diagnosis, preoperative planning, and follow-up of thoracic and thoraco-abdominal aortic diseases (weak recommendation in favor, level of evidence 2-).

PICO 3.3

In patients with thoracic and thoraco-abdominal aortic diseases (P), should multiplanar and 3D image reconstruction software (I) be used to achieve greater diagnostic accuracy and correct preoperative planning (O)?

Recommendation

The use of advanced diagnostic and planning software is indicated for diagnosis and preoperative planning of thoracic and thoraco-abdominal aortic diseases (strong recommendation in favor, level of evidence 2-).

PICO 3.4

In patients with thoracic and thoraco-abdominal aortic diseases candidates for endovascular treatment (P), is intravascular ultrasound (IVUS) (I) an accurate examination to achieve greater diagnostic accuracy and correct preoperative planning (O)?

Recommendation

The use of intravascular ultrasound (IVUS) may be indicated to obtain more accurate measurements of aortic diameters and landing zones in the operative planning of endovascular treatments for thoracic aortic diseases (weak recommendation in favor, level of evidence 2-).

PICO 3.5

In patients with thoracic and thoraco-abdominal aortic diseases candidates for endovascular treatment (P), is intraoperative 3D image fusion (fusion imaging) (I) a suitable method to reduce operative times, exposure to ionizing radiation, and use of iodinated contrast medium (O)?

Recommendation

The use of intraoperative 3D image fusion (fusion imaging) may be indicated in the endovascular treatment of thoracic and thoraco-abdominal aortic diseases to reduce operative time, exposure to ionizing radiation, and use of iodinated contrast medium (weak recommendation in favor, level of evidence 2+).

PICO 3.6

In patients with thoracic and thoraco-abdominal aortic diseases undergoing endovascular exclusion with branched or fenestrated stent-grafts (P), is intra-procedural cone beam computed tomography (CBCT) (I) a suitable method to achieve early diagnosis of intraoperative complications and reduce the reintervention rate (O)?

Recommendation

The use of intra-procedural CBCT may be indicated to evaluate any complications during the implantation of fenestrated or branched stent-grafts and allow immediate correction, reducing the early reintervention rate (weak recommendation in favor, level of evidence 2+).

PICO 4.1

Does optimizing spinal cord perfusion pressure (I) decrease the incidence of spinal cord ischemia (O) in patients undergoing traditional or endovascular surgery for acute thoracic or thoraco-abdominal aortic disease (P)?

Recommendation

In patients treated for acute thoracic and thoraco-abdominal aortic disease via endovascular and traditional surgical approaches, it is suggested to maintain mean arterial pressure between 80 and 100 mmHg during the procedure and for 72 hours post-procedure to reduce the incidence of spinal cord ischemia (GPP).

PICO 4.2

Does moderate hypothermia (I) decrease the incidence of spinal cord ischemia (O) in patients undergoing open surgery for acute thoracic or thoraco-abdominal aortic disease (P)?

Recommendation

In patients undergoing traditional surgical treatment for acute thoracic aortic disease, it is suggested to use moderate hypothermia in conjunction with other methods to prevent spinal cord ischemia (GPP).

PICO 4.3

Do renal protection techniques pre- and intra-operatively (preoperative hydration, intra-operative mannitol infusion, cold perfusion of renal arteries with crystalloids or blood) (I) decrease the incidence of postoperative acute renal injury (O) in patients undergoing traditional or endovascu-

lar surgery for acute thoracic or thoraco-abdominal aortic disease (P)?

Recommendations

1. In patients surgically treated for thoracic aortic disease, good preoperative hydration and intraoperative mannitol administration are suggested to prevent acute renal injury (GPP).

2. In patients surgically treated for thoracic and thoraco-abdominal aortic disease requiring clamping or temporary exclusion of renal arteries, perfusion with cold crystalloid solutions or blood is suggested to prevent acute renal injury (GPP).

PICO 4.4

In patients with ruptured thoracic aneurysm (P), does endovascular treatment (I) compared to traditional surgical intervention (C) improve clinical outcomes (O)?

Recommendation

In patients with ruptured descending thoracic aortic aneurysm, endovascular treatment is indicated as the first option for patients with appropriate anatomy (strong recommendation in favor, level of evidence 1+).

PICO 4.5

In patients with ruptured thoraco-abdominal aneurysm (P), does endovascular treatment (I) compared to traditional surgical intervention (C) improve clinical outcomes (O)?

Recommendations

1. In hemodynamically unstable patients with ruptured thoraco-abdominal aneurysm, traditional surgery is indicated as the first-choice treatment in centers with adequate resources and experience (strong recommendation in favor, level of evidence 4).

2. In hemodynamically stable patients with ruptured thoraco-abdominal aneurysm, endovascular treatment is suggested as a valid alternative to traditional surgical treatment in patients with favorable anatomy in centers with adequate resources and experience (GPP).

PICO 4.6

In patients with ruptured thoracic aneurysm and genetic syndromes (P), does endovascular treatment (I) compared to traditional surgical treatment (C) improve clinical outcomes (O)?

Recommendations

1. In patients with connective tissue genetic syndromes and ruptured descending thoracic aortic aneurysm, traditional surgical treatment may be indicated as first choice treatment in centers with adequate resources and experience (weak recommendation in favor, level of evidence 4).

2. In hemodynamically unstable patients with connective tissue genetic syndromes and ruptured descending thoracic aortic aneurysm, endovascular treatment may be indicated as a life-saving bridge therapy aimed at stabilizing the patient (weak recommendation in favor, level of evidence 4).

PICO 4.7

In patients with ruptured thoraco-abdominal aneurysm and genetic syndromes (P), does endovascular treatment (I) compared to traditional surgical treatment (C) improve clinical outcomes (O)?

Recommendation

In patients with genetic syndromes of connective tissue disorders and ruptured thoraco-abdominal aneurysm, traditional surgical treatment is indicated as the first-choice treatment in centers with adequate resources and experience (strong recommendation in favor, level of evidence 2-).

PICO 4.8

Does early placement of thoracic drainage (I) in patients with hemothorax secondary to ruptured thoracic or thoraco-abdominal aneurysm (P) decrease the incidence of respiratory complications (O) compared to late placement or non-placement (C)?

Recommendation

In case of hemothorax secondary to ruptured thoracic and thoraco-abdominal aneurysm, early placement of pleural drainage may be indicated compared to late placement or non-placement, both in surgical and endovascular treatment (weak recommendation in favor, level of evidence 2+).

PICO 5.1

In patients with descending thoracic aortic aneurysm (P), is endovascular treatment (I) preferable to open surgery (C) to improve clinical outcomes (O)?

Recommendations

1. In patients with atherosclerotic descending thoracic aortic aneurysm larger than 5.5 cm in diameter, endovascular treatment is indicated, if anatomically feasible, over open surgery (strong recommendation in favor, level of evidence 1++).

2. In low-surgical-risk patients with atherosclerotic descending thoracic aortic aneurysm larger than 5.5 cm in diameter, in the presence of unfavorable anatomy for endovascular treatment, open treatment might be indicated (weak recommendation in favor, level of evidence 2-).

PICO 5.2

In patients with thoracic aortic blunt injury(P), does endovascular treatment (I) improve outcomes (O) compared to open surgical treatment (C)?

Recommendations

1. In patients with grade II, III, and IV thoracic aortic blunt injury, endovascular treatment is indicated (strong recommendation in favor, level of evidence 1++).
2. In patients with grade I thoracic aortic blunt injury, urgent surgical/endovascular treatment is not considered appropriate, but medical therapy and Angio-CT control within 24 hours of the event are suggested (GPP).
3. In patients with thoracic aortic blunt injury, in case of contraindications to endovascular treatment, where the patient's general clinical conditions allow, open surgical treatment might be indicated (weak recommendation against, level of evidence 1+).

PICO 6.1

In patients with thoraco-abdominal aortic aneurysm, under what conditions are medical therapy, surgical treatment, and endovascular treatment indicated?

Recommendations

1. In patients with thoraco-abdominal aneurysm, in the absence of genetic pathology, endovascular or surgical treatment is indicated when the diameter is 55 mm, based on the patient's fitness and anatomy (strong recommendation in favor, level of evidence 2+).
2. In patients candidates for thoraco-abdominal aneurysm treatment, a preoperative evaluation of cardiological risk factors using second-level diagnostics, neurological, and pulmonary assessments is indicated to guide the therapeutic direction: Open or Endo (strong recommendation in favor, level of evidence 2+).
3. In patients not suitable for open surgical treatment of thoraco-abdominal aneurysms, in the absence of connective tissue diseases, an endovascular procedure might be indicated (weak recommendation in favor, level of evidence 2-).
4. In patients not suitable for surgical treatment of thoraco-abdominal aneurysms with unfavorable aortic anatomy for fenestrated/branched stent-grafts, alternative endovascular/hybrid procedures are indicated (strong recommendation in favor, level of evidence 2+).

PICO 6.2

Which spinal cord monitoring and protection techniques improve neurological outcomes in patients undergoing surgical and endovascular treatment for thoraco-abdominal aortic aneurysm?

Recommendations

1. In patients with type I, II, and III thoraco-abdominal aneurysm candidates for surgical treatment, the use of CSFD may be indicated (weak recommendation in favor, level of evidence 1+).
2. In patients with type I, II, and III thoraco-abdominal aneurysm candidates for surgical treatment, distal aortic perfusion may be indicated (weak recommendation in favor, level of evidence 2+).
3. In patients with type I, II, and III thoraco-abdominal aneurysm candidates for surgical treatment, perioperative monitoring of motor and/or somato-sensory evoked potentials may be indicated to predict spinal cord ischemia (weak recommendation in favor, level of evidence 2-).
4. In patients with type I, II, and III thoraco-abdominal aneurysm candidates for surgical treatment, hypothermia around 32 °C may be considered to prevent spinal cord damage (weak recommendation in favor, level of evidence 1-).
5. In patients with thoraco-abdominal aneurysm candidates for endovascular treatment, revascularization of the subclavian artery may be indicated (weak recommendation in favor, level of evidence 2+).
6. Staged planning of endovascular treatment for thoraco-abdominal aneurysms may be indicated (weak recommendation in favor, level of evidence 1+).

PICO 6.3

In patients with infected thoraco-abdominal aortic grafts/endografts, with or without fistula, does invasive treatment compared to non-invasive treatment improve clinical outcomes?

Recommendations

1. In low surgical risk patients with graft infection, complete explant is indicated (strong recommendation in favor, level of evidence 2+).
2. In patients with suspected thoracic/thoraco-abdominal graft infection, in the absence of fistulization or sepsis, prolonged antibiotic therapy combined with fluid drainage

and/or irrigation may be considered (weak recommendation in favor, level of evidence 1-).

3. In patients with limited graft infection, partial explant might be indicated (weak recommendation in favor, level of evidence 1-).

4. In patients with hemorrhage, in case of emergency, endovascular treatment might be indicated as a life-saving bridge treatment (weak recommendation in favor, level of evidence 1+).

PICO 7.1

In patients with asymptomatic aortic arch aneurysm ≥5.5 cm (P), is open/endo/hybrid treatment (I) indicated over medical therapy (C) for the prevention of complications (O)?

Recommendations

1. Open treatment is indicated in low surgical risk patients with asymptomatic aortic arch aneurysm ≥5.5 cm (strong recommendation in favor, level of evidence 2++).

2. Endovascular/hybrid treatment is indicated in high surgical risk patients or those with a history of previous aortic surgery with asymptomatic aortic arch aneurysm ≥5.5 cm (strong recommendation in favor, level of evidence 2++).

3. Best medical therapy as the only form of treatment is not indicated in patients with asymptomatic aortic arch aneurysm ≥5.5 cm (strong recommendation in favor, level of evidence 2++).

PICO 7.2

In patients with aortic arch aneurysm >4.5 cm with growth ≥5 mm/year (P), is medical treatment (I) more indicated than open/endo/hybrid surgical treatment (C) in reducing the risk of rupture (O)?

Recommendations

1. In patients with aortic arch aneurysm >4.5 cm with growth ≥5 mm/year, medical therapy combined with close instrumental monitoring may be indicated over surgical treatment to reduce the risk of rupture (weak recommendation in favor, level of evidence 2+).

2. Surgical treatment may be indicated in patients with aortic arch aneurysm >4.5 cm with growth ≥5 mm/year associated with connective tissue diseases or bicuspid aortic valve (weak recommendation in favor, level of evidence 2++).

PICO 7.3

In patients with asymptomatic aortic arch aneurysm ≥5.5 cm (P), is open treatment (I) more indicated compared to endo/hybrid treatment (C) in preventing complications (O)?

Recommendations

1. For isolated aortic arch aneurysms, open treatment is indicated in patients under 75 years old at low surgical risk (strong recommendation in favor, level of evidence 2++).

2. For isolated aortic arch aneurysms in patients over 75 years old or at high surgical risk, hybrid or endovascular treatment is indicated (strong recommendation in favor, level of evidence 2++).

PICO 7.4

In patients with chronic dissection (P), does the use of beta blockers (I) offer a therapeutic advantage over other categories of antihypertensive drugs (C) (O)?

Recommendations

1. Systolic pressure values within 120 mmHg, diastolic pressure within 80 mmHg, and heart rate not exceeding 60 beats per minute are indicated in patients with chronic dissection (strong recommendation in favor, level of evidence 1+).

2. The use of beta blockers alone may be indicated in patients with chronic dissection to improve clinical outcomes (weak recommendation in favor, level of evidence 4).

3. The use of beta blockers or calcium antagonists combined with other antihypertensive drugs may be indicated for treatment of patients with chronic dissection (weak recommendation in favor, level of evidence 4).

PICO 7.5

In patients with chronic dissection (P), is medical therapy (I) preferable to surgical treatment (open/endovascular) (C) in terms of disease progression, aortic events, and mortality (O)?

Recommendations

1. Medical therapy alone may be indicated in patients with chronic dissection who had an uncomplicated presentation within the first two years from the acute event (weak recommendation in favor, level of evidence 2+).

2. Endovascular or open treatment is indicated in patients with an aortic diameter ≥55 mm (strong recommendation in favor, level of evidence 2++).

3. Endovascular treatment may be indicated in patients with an initial aortic diameter (in the acute phase) ≥40 mm (weak recommendation in favor, level of evidence 2++).

PICO 7.6

In patients with chronic dissection (P), does endovascular treatment (I) offer advantages over open surgical treatment (C) in terms of mortality, complications, and reinterventions (O)?

Recommendations

1. Endovascular treatment is indicated in patients with chronic dissection at high surgical risk (strong recommendation in favor, level of evidence 2++).
2. Endovascular treatment is indicated as an alternative to open treatment in patients with chronic dissection at low surgical risk with favorable anatomy (strong recommendation in favor, level of evidence 1+).
3. In patients with chronic dissections and connective tissue diseases at low surgical risk, open treatment is indicated (strong recommendation in favor, level of evidence 2++).
4. In patients with chronic dissections and connective tissue diseases at high risk for open surgery, endovascular treatment is suggested as an alternative or complement to open treatment (GPP).

PICO 8.1

In adult patients with aortic coarctation (P), what diagnostic techniques (I/C) can provide supportive information for clinical diagnosis to indicate surgical treatment (O)?

Recommendation

For the study of aortic coarctations, a multimodal diagnostic approach with a particularly privileged role of 4D Cardiac Magnetic Resonance providing both morphological and dynamic elements might be indicated (weak recommendation in favor, level of evidence 2-).

PICO 8.2

In adult patients with aortic coarctation (P), is an open (I) or endovascular (C) approach preferable for improving outcomes (O)?

Recommendation

The endovascular approach might be indicated as an alternative to open surgery for treating aortic coarctations (weak recommendation in favor, level of evidence 2+).

PICO 8.3

In case of aortic atheroma (P), is medical treatment (I) indicated compared to no treatment (C) to reduce the risk of embolic events (O)?

Recommendation

In patients with aortic atheroma, anticoagulant or antiplatelet therapy is indicated to prevent progression and reduce the risk of embolic events (strong recommendation in favor, level of evidence 1+).

PICO 8.4

In patients with symptomatic mural thrombus or floating thrombus (P), is surgical therapy (I) indicated over conservative treatment (C) to reduce embolic events (O)?

Recommendations

1. In patients with mural thrombus, anticoagulant therapy is indicated (Strong recommendation in favor, level of evidence 2+).
2. In patients with symptomatic or floating mural thrombus, prompt open or endovascular surgical intervention might be indicated (Weak recommendation in favor, level of evidence 2+).

PICO 8.5

In patients with aortic tumor (P), is surgical intervention (I) indicated over conservative therapy (C) to improve survival (O)?

PICO 8.6

In patients undergoing open or endovascular thoracic aortic surgery (P), do instrumental controls (I) rather than clinical observation (C) offer advantages in detecting complications (O)?

Recommendations

1. In case of open or endovascular treatment of thoracic aorta pathologies, instrumental follow-up is indicated in the short, medium, and long term (strong recommendation in favor, level of evidence 2+).
2. In choosing the type of instrumental examination and follow-up frequency, the need to reduce exposure to ionizing radiation over time and prevent contrast-induced nephropathy is suggested. (GPP).

Discussion

The primary purpose was to provide a GL suitable to trace and suggest appropriate and more complete diagnostic and therapeutic indications for the medical and surgical management of patients with pathologies of the thoracic-abdominal aorta according to the most recent evidence in the

current literature, selected and processed according to the EBM methodological criteria. In most cases, already existing recommendations were confirmed by the most reliable studies available today and then re-proposed with minor updates, where appropriate. However, some aspects were reassessed. Regarding the management of the aortic dissection the importance of CTA as the methodology of primary diagnosis is remarkable, also the primary role of endovascular surgery on its treatment was established. Also, about dissection non-A non-B, mural hematoma and penetrating ulcers the newest indications about treatment, management in either uncomplicated and complicated cases were revised. The use of advanced diagnostic and planning software is indicated for diagnosis and preoperative planning of thoracic and thoraco-abdominal aortic diseases in all cases and the use during intra-operative time of IVUS, 3D image fusion or CBCT may help to improve the operatory timing and the post-operative complications if available. Regarding the rupture of descending thoracic aorta aneurysms, the endovascular surgery is indicated as a strong indication with a high level of evidence. As for the connective tissue genetic syndromes and ruptured descending thoracic aorta there is new evidence in literature about the bridging therapy using endovascular therapy as first indication even though the open surgery remains the main indication for the treatment. Harky *et al.*[91] in a systematic review and meta-analysis compared the results of open and endovascular treatment of descending thoracic aortic aneurysms, reporting a clear advantage for endovascular intervention in terms of hospital stay, paraplegia, renal and cardiac complications so the TEVAR comes as a strong indication for patients with atherosclerotic descending thoracic aortic aneurysm larger than 5.5 cm in diameter, over open surgery. Regarding thoracic aortic blunt injury, we reported accurate indications in terms of phases of the pathology and TEVAR over open surgery. There are no strong indications about spinal cord monitoring and protection techniques to improve neurological outcomes because of controversial opinions in literature, thus techniques such as CFSD, MEP, SEPS and revascularization of the left subclavian artery may be indicated as week recommendations. An important aspect of these GL was also to define better the treatment of graft infection. In a systematic review and meta-analysis involving 96 patients with infected thoracic endografts, 41 had EG explant, and 55 had EG preservation, with mortality rates of 37% *vs*. 42%, respectively, while late mortality was 46% *vs*. 82% for EG explant and EG preservation, respectively. In a meta-analysis, one-year mortality was 37% (15/41) for total surgical graft explant *vs.* 85% (17/20) for partial or total graft preservation. Therefore, the authors focused on the need of customizing the indications considering different components. Moreover, compared to the International Guidelines and the previous Italian guidelines the authors aimed to shed light on the endovascular and open surgical approach in patients with different kind and situations aortic arch aneurysm modeling new indications. This GL is characterized by the constant consideration of Personalized Medicine, from the beginning and at each step, of topics definition, research questions, analysis of the evidence in the literature, sharing of the judgments, and final recommendations. More or fewer clear-cut recommendations were issued when the evidence (or absence of evidence in case of GPP) in the literature and the assessments of the multidisciplinary authors and the various stakeholders allowed it.

Conclusions

These Guidelines are intended to outline the most correct management of patients affected by thoracic and thoracoabdominal aortic diseases, according to the most recent and reliable indications provided by the current Literature, selected following strict methodological criteria of scientific research and selection. This review highlighted the need to update many existing recommendations over time ad to add some new recommendations as well as to provide research ideas for subjects where the scientific evidence is still not solid.

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The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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