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GUIDELINES

VASCULAR SECTION

Guidelines on the diagnosis, treatment and management of visceral and renal arteries aneurysms: a joint assessment by the Italian Societies of Vascular and Endovascular Surgery (SICVE) and Medical and Interventional Radiology (SIRM)

Carlo PRATESI [1], Davide ESPOSITO [1] *, Romeo MARTINI [2], Claudio NOVALI [3], Augusto ZANINELLI [4], Antonio L. ANNESE [5], Paolo BAGGI [6], Raffaello BELLOSTA [7], Claudio BIANCHINI MASSONI [8], Stefano BONARDELLI [6], Serena CARRIERO [9], Rosa CERVELLI [10], Emiliano CHISCI [11], Roberto CIONI [10], Fabio CORVINO [12], Francesco DE COBELLI [13], Fabrizio FANELLI [5], Aaron T. FARGION [1], Marco FEMIA [14], Antonio FREYRIE [8], Andrea GAGGIANO [15], Enrico GALLITTO [16], Stefano GENNAI [17], Emanuela GIAMPALMA [18], Francesco GIURAZZA [12], Franco GREGO [19], Giorgia GUAZZAROTTI [13], Anna M. IERARDI [9], Andrea L. KAHLBERG [20], Daniele MASCIA [20], Luca MEZZETTO [21], Stefano MICHELAGNOLI [11], Floriana NARDELLI [22], Raffaella NIOLA [12], Massimo LENTI [23], Orsola PERRONE [10], Filippo PIACENTINO [24], Gabriele PIFFARETTI [25], Raffaele PULLI [1], Gino PUNTEL [26], Giovanni PUPPINI [26], Denis ROSSATO [22], Michele ROSSI [27], Roberto SILINGARDI [17], Pasqualino SIRIGNANO [28], Francesco SQUIZZATO [19], Marcello A. TIPALDI [27], Massimo VENTURINI [24], Gian F. VERALDI [21], Antonio VIZZUSO [18], Sara ALLIEVI [7], Luca ATTISANI [7], Gianluigi FINO [23], Francesca GHIRARDINI [2], Paola MANZO [15], Mattia MIGLIARI [17], Stephanie STEIDLER [13], Vittorio MIELE [5], Maurizio TAURINO [28], Massimiliano ORSO [29], Maurizio CARIATI [14] for the Italian Guidelines for Vascular and Endovascular Surgery Collaborators ‡

[1]Department of Vascular Surgery, Careggi University Hospital, Florence, Italy; [2]Department of Angiology, San Martino Hospital, Belluno, Italy; [3]Department of Vascular Surgery, GVM Maria Pia Hospital, Turin, Italy; [4]General Medical Practice, Bergamo, Italy; [5]Department of Diagnostic and Interventional Radiology, Careggi University Hospital, Florence, Italy; [6]Department of Vascular Surgery, ASST Spedali Civili, Brescia, Italy; [7]Department of Vascular Surgery, Fondazione Poliambulanza, Brescia, Italy; [8]Department of Vascular Surgery, University Hospital of Parma, Parma, Italy; [9]Department of Diagnostic and Interventional Radiology, Fondazione IRCCS Cà Granda Ospedale Maggiore Policlinico, Milan, Italy; [10]Department of Diagnostic and Interventional Radiology, A.O.U. Pisana, Pisa, Italy; [11]Department of Vascular Surgery, S. Giovanni di Dio Hospital, Florence, Italy; [12]Department of Diagnostic and Interventional Radiology, AORN Cardarelli, Naples, Italy; [13]Department of Diagnostic and Interventional Radiology, San Raffaele Hospital, Milan, Italy; [14]Department of Diagnostic and Interventional Radiology, ASST Santi Paolo e Carlo, Milan, Italy; [15]Department of Vascular Surgery, Umberto I Mauriziano Hospital, Turin, Italy; [16]Department of Vascular Surgery, S. Orsola-Malpighi University Hospital, Bologna, Italy; [17]Department of Vascular Surgery, Baggiovara Hospital, Modena, Italy; [18]Department of Diagnostic and Interventional Radiology, Morgagni-Pierantoni Hospital, Forlì, Italy; [19]Department of Vascular Surgery, University Hospital of Padua, Padua, Italy; [20]Department of Vascular Surgery, San Raffaele Hospital, Milan, Italy; [21]Department of Vascular Surgery, University Hospital of Verona, Verona, Italy; [22]Department of Diagnostic and Interventional Radiology, Città della Salute e della Scienza, Turin, Italy; [23]Department of Vascular Surgery, S. Maria della Misericordia Hospital, Perugia, Italy; [24]Department of Diagnostic and Interventional Radiology, Circolo Hospital, Varese, Italy; [25]Department of Vascular Surgery, ASST dei Sette Laghi, Varese, Italy; [26]Department of Diagnostic and Interventional Radiology, University Hospital of Verona, Verona, Italy; [27]Department of Diagnostic and Interventional Radiology, Sant'Andrea University Hospital, Rome, Italy; [28]Department of Vascular Surgery, Sant'Andrea University Hospital, Rome, Italy; [29]Istituto Zooprofilattico Sperimentale dell'Umbria e delle Marche, Perugia, Italy

‡Members are listed at the end of the paper

*Corresponding author: Davide Esposito, Department of Vascular Surgery, University of Florence, Largo Brambilla 3, 50134 Florence, Italy.
E-mail: davide.esposito@unifi.it

ABSTRACT

The objective of these Guidelines is to provide recommendations for the classification, indication, treatment and management of patients suffering from aneurysmal pathology of the visceral and renal arteries. The methodology applied was the GRADE-SIGN version, and followed the instructions of the AGREE quality of reporting checklist. Clinical questions, structured according to the PICO (Population, Intervention, Comparator, Outcome) model, were formulated, and systematic literature reviews were carried out according to them. Selected articles were evaluated through specific methodological checklists. Considered Judgments were compiled for each clinical question in which the characteristics of the body of available evidence were evaluated in order to establish recommendations. Overall, 79 clinical practice recommendations were proposed. Indications for treatment and therapeutic options were discussed for each arterial district, as well as follow-up and medical management, in both candidate patients for conservative therapy and patients who underwent treatment. The recommendations provided by these guidelines simplify and improve decision-making processes and diagnostic-therapeutic pathways of patients with visceral and renal arteries aneurysms. Their widespread use is recommended.

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KEY WORDS: Aneurysm; Renal artery; Vascular surgical procedures; Practice guideline; Systematic review.

These Guidelines have been accepted by the Italian National Institute of Health, and published in Italian language on 28th of April 2023 on the National Guidelines System (https://snlg.iss.it/).

Aim of the study was to present Italian Guidelines on the management of Visceral and Renal arteries Aneurysm disease, developed in accordance with the instructions of the National Guidelines System (SNLG) Methodological Manual, and approved by the Italian National Institute of Health.

The main objective of these Guidelines is to provide the correct diagnostic and therapeutic pathway, to be shared between doctor and patient, to guide and optimize the diagnostic and treatment decisions.

The methodology applied in these Guidelines is the GRADE-SIGN version,[1] also referring to the methodological indications contained in the Procedures for the submission and evaluation of Guidelines for publication in the SNLG - Operational Manual[2] and the Methodological Manual for the production of clinical practice guidelines,[3] by the National Center for Clinical Excellence, Quality and Safety of Care (CNEC). The Guidelines were developed according to the AGREE quality of reporting checklist[4] and, once completed, were assessed using the AGREE II tool.[5]

The multidisciplinary panel included the following specializations: vascular surgery, interventional radiology, angiology, and general medicine. In addition to the Italian Society of Vascular and Endovascular Surgery (SICVE) and the Italian Society of Medical and Interventional Radiology (SIRM), which were the proposing societies, the Italian Society of Angiology and Vascular Pathology (SIAPAV) and the Italian Interdisciplinary Society for Primary Care (SIICP) were involved from the production of these Guidelines. The Guidelines were also evaluated in terms of applicability for the patient by the Vascular Patients Association Titoccotoccati, which shared and approved all the proposed recommendations. Guidelines were built in accordance with the same methodology adopted for the development of previously published official national guidelines.[6, 7] The systematic review processes and the interpretation of selected evidence to build recommendations are available in the Supplementary Digital Material 1 (Supplementary Table I-XIII, Supplementary Figure 1-22, Supplementary Text File 1).

Diagnosis and screening

PICO 1.1 Clinical question

In patients with suspected aneurysm/pseudoaneurysm of visceral or renal artery, is computed tomography (CT) angiography more accurate than other modalities for the diagnosis and indication for treatment?

Recommendation[8-13]

In patients with suspected aneurysm/pseudoaneurysm of the visceral or renal artery, CT angiography is suggested

as the preferred imaging modality for the diagnosis and indication for treatment, in both urgent and elective cases.

Good Practice Point (GPP) recommendation.

PICO 1.2 Clinical question

Should patients diagnosed with visceral or renal artery aneurysms be screened with additional imaging to look for potential concomitant aneurysms in different locations to prevent complications, instead of forgoing further diagnostic examinations?

Recommendation

In patients diagnosed with visceral or renal artery aneurysms, careful evaluation of radiological images is suggested to assess the presence of concurrent aneurysms in the examined regions.

Good Practice Point (GPP) recommendation.

PICO 1.3 Clinical question

Should patients with visceral or renal artery aneurysms be screened for associated underlying pathologies?

Recommendation

In patients with visceral or renal artery aneurysms, screening for associated underlying pathologies is suggested, such as fibromuscular dysplasia tests and ultrasound examination for concomitant popliteal artery aneurysms.[14, 15]

Good Practice Point (GPP) recommendation.

Indications and treatment options: renal artery aneurysms

PICO 2.1.1 Clinical question

In a patient with an aneurysm/pseudoaneurysm of the renal arteries, when is it justified to propose a surgical/endovascular treatment compared to medical therapy/follow-up alone to improve the outcome?

Recommendations[16-23]

In case of renal artery aneurysm with a diameter greater than or equal to 3 cm and with acceptable operative risk, elective repair is recommended.

Strong recommendation for (level of evidence 2++).

The treatment of a renal artery aneurysm with a diameter of less than 3 cm is suggested in the following cases: distal location, saccular morphology, and rapid growth.

Good Practice Point (GPP) recommendation.

It is suggested to treat renal artery pseudoaneurysms regardless of size, due to the high risk of rupture.

Good Practice Point (GPP) recommendation.

In the patient with symptomatic renal artery aneurysm/pseudoaneurysm, urgent intervention is recommended regardless of the size of the aneurysm.

Strong recommendation for (level of evidence 2++).

Emergency repair is recommended in case of ruptured renal artery aneurysm/pseudoaneurysm.

Strong recommendation for (level of evidence 2++).

In patients of childbearing age with renal artery aneurysm and with acceptable operative risk, treatment is suggested even in the case of diameters of less than 3 cm, taking into account the specific peculiarities of the individual case.

Good Practice Point (GPP) recommendation.

PICO 2.1.2 Clinical question

Which intervention/procedure is preferable in terms of outcome in patients with renal artery aneurysm/pseudoaneurysm?

Recommendations[16, 17, 24-30]

In elective patients with an aneurysm/pseudoaneurysm of the renal artery and acceptable operative risk, consider open surgical treatment.

Conditional recommendation for (level of evidence 2++).

It is suggested to consider *ex-vivo* repair with autotransplant rather than nephrectomy in case of distal renal artery aneurysms.

Good Practice Point (GPP) recommendation.

In case of aneurysm/pseudoaneurysm of renal artery main branch, consider an endovascular approach with stent placement if the anatomy is judged favorable and logistically achievable. Consider endovascular embolization of a distal branch aneurysm in patients judged at high risk for the open repair.

Conditional recommendation for (level of evidence 2++).

Indications and treatment options: splenic artery aneurysms

PICO 2.2.1 Clinical question

When is it justified to propose surgical/endovascular treatment, compared with medical therapy/follow-up alone, to improve the outcomes of patients with a splenic artery aneurysm/pseudoaneurysm?

Recommendations[16, 31-57]

Emergency treatment is recommended in case of ruptured splenic artery aneurysms/pseudoaneurysms.

Strong recommendation for (level of evidence 2+).

Emergency treatment is recommended in case of symptomatic splenic artery aneurysms/pseudoaneurysms regardless of size, due to the high risk of rupture.

Strong recommendation for (level of evidence 2+).

The treatment of splenic artery pseudoaneurysms is recommended as soon as possible, regardless of size, due to the high risk of rupture.

Strong recommendation for (level of evidence 2+).

In cases of splenic artery aneurysms greater than or equal to 3 cm in diameter, elective treatment is recommended, unless major contraindications exist.

Strong recommendation for (level of evidence 2+).

Consider elective treatment in case of splenic artery aneurysms ranging from 2 to 3 cm in diameter, unless major contraindications exist.

Conditional recommendation for (level of evidence 3).

Surveillance of true splenic artery aneurysms is suggested in case of: 1) less than 3 cm in diameter, 2) demonstrated dimensional stability, 3) significant comorbidities, 4) limited life expectancy.

Good Practice Point (GPP) recommendation.

In case of splenic artery aneurysms less than 2 cm in diameter, elective treatment is suggested in case of demonstrated and rapid volumetric growth, unless major contraindications exist.

Good Practice Point (GPP) recommendation.

In case of splenic artery aneurysm in liver transplant patient or patients with portal hypertension, consider treatment regardless of size, unless major contraindications exist.

Conditional recommendation for (level of evidence 3).

In case of splenic artery aneurysm in women of childbearing age, treatment is suggested if there is demonstrated and rapid volumetric growth and regardless of size, unless major contraindications exist.

Good Practice Point (GPP) recommendation.

PICO 2.2.2 Clinical question

In a patient with a splenic artery aneurysm/pseudoaneurysm, which intervention/procedure should be carried out in order to obtain better outcomes?

Recommendations[31, 41-43, 52, 53, 55, 58-71]

In the emergency setting, it is recommended to choose the type of treatment (surgical versus endovascular) for ruptured splenic artery aneurysm/pseudoaneurysm on the basis of its feasibility.

Strong recommendation for (level of evidence 2+).

In the elective setting, it is recommended to choose the type of treatment (surgical versus endovascular) for splenic artery aneurysms/pseudoaneurysms on the basis of clinical, anatomical, multidisciplinary, and logistic assessments.

Strong recommendation for (level of evidence 2+).

Whenever possible, based on clinical, anatomical, multidisciplinary, and logistic assessments, it is suggested to prefer the endovascular treatment over a surgical solution, because of its less invasiveness, fewer complications, cost-effectiveness.

Good Practice Point (GPP) recommendation.

Whenever possible, based on clinical, anatomical, multidisciplinary, and logistic assessments, it is suggested to prefer the surgical treatment over endovascular solutions in cases of giant aneurysms (more than 5 cm in diameter) causing compressive effects.

Good Practice Point (GPP) recommendation.

Indications and treatment options: celiac artery aneurysms

PICO 2.3.1 Clinical question

In patients with celiac artery aneurysm/pseudoaneurysm, when is surgical and/or endovascular intervention indicated against medical therapy alone to reduce the risk of rupture?

Recommendations[16, 38, 72-94]

In cases of celiac artery aneurysm, treatment is recommended regardless of size, if ruptured (in emergency) or symptomatic (in urgency).

Strong recommendation for (level of evidence 2-).

In cases of non-ruptured pseudoaneurysm of the celiac artery, treatment is recommended regardless of size, in patients with acceptable surgical risk.

Strong recommendation for (level of evidence 2-).

In cases of non-ruptured aneurysm of the celiac artery, treatment is recommended when size/diameter is greater than or equal to 2 cm, in patients with acceptable surgical risk.

Strong recommendation for (level of evidence 2+).

Consider treatment of non-ruptured celiac artery aneurysms less than 2 cm in size in cases of: non-atherosclerotic etiology, cases with documented rapid growth, patients in whom hepatic transplantation is planned.

Conditional recommendation for (level of evidence 3).

In cases of celiac artery aneurysm in pregnant women/women of childbearing age, treatment is suggested regardless of size for non-atherosclerotic aneurysms, cases with documented rapid growth, patients in whom hepatic transplantation is planned.

Good Practice Point (GPP) recommendation.

PICO 2.3.2 Clinical question

In patients with celiac artery aneurysm/pseudoaneurysm, with an indication for intervention, is endovascular treatment more suitable than open surgery to improve clinical success?

Recommendations[9, 16, 72-77, 79-90, 93-104]

In patients with celiac artery aneurysm and favorable anatomy, the endovascular intervention is recommended as the first-choice treatment modality.

Strong recommendation for (level of evidence 2-).

In patients with indication for treatment of celiac artery aneurysm, revascularization (stenting, bypass or direct reimplant) is recommended over vessel occlusion (embolization or ligature).

Strong recommendation for (level of evidence 2-).

In patients with indication for endovascular revascularization, consider preserving the hepatic artery rather than the splenic artery, particularly when collateral circulation is not adequate.

Conditional recommendation for (level of evidence 3).

A preoperative selective angiography is suggested to verify adequate collateral circulation, particularly when vessel occlusion might be necessary.

Good Practice Point (GPP) recommendation.

Indications and treatment options: gastropancreaticoduodenal arteries aneurysms

PICO 2.4.1 Clinical question

In patients with aneurysms of the gastropancreaticoduodenal arteries, when is it justified to propose a surgical/endovascular treatment rather than medical therapy/follow-up alone to improve the outcomes?

Recommendation[105-108]

In case of asymptomatic gastropancreaticoduodenal aneurysm, the elective repair is recommended regardless of size.

Strong recommendation for (level of evidence 2++).

PICO 2.4.2 Clinical question

In patients with aneurysms of the gastropancreaticoduodenal arteries, which intervention/procedure is preferable in terms of outcomes?

Recommendations[16, 105-109]

In patients with gastropancreaticoduodenal aneurysms, the endovascular approach is recommended, both in the elective and urgent settings, as the first-choice option in the presence of a favorable anatomy.

Strong recommendation for (level of evidence 2++).

In patients with a gastropancreaticoduodenal aneurysm associated with steno-occlusion of the coeliac artery, the revascularisation of the latter might not be considered.

Conditional recommendation against (level of evidence 3).

In patients with gastropancreaticoduodenal aneurysms and steno-occlusion of the coeliac artery with associated obstructive lesions of the superior and inferior mesenteric artery, the revascularisation of the coeliac artery is suggested.

Good Practice Point (GPP) recommendation.

PICO 2.4.3 Clinical question

In patients with pseudoaneurysms of the gastropancreaticoduodenal arteries, when is it justified to propose a surgical/endovascular treatment rather than medical therapy/follow-up alone to improve the outcomes?

Recommendations[109, 110]

Emergency treatment is suggested in case of ruptured pseudoaneurysm of the gastroduodenal artery or pancreaticoduodenal arch associated with active bleeding.

Good Practice Point (GPP) recommendation.

Elective treatment is suggested as soon as possible in case of pseudoaneurysms of the gastroduodenal artery or the pancreaticoduodenal arch not associated with ongoing bleeding and regardless of the size of the pseudoaneurysm itself.

Good Practice Point (GPP) recommendation.

PICO 2.4.4 Clinical question

In patients with pseudoaneurysms of the gastropancreaticoduodenal arteries, which intervention/procedure is preferable in terms of outcomes?

Recommendations[109-116]

It is suggested to choose the type of emergency treatment (open or endovascular) of ruptured pseudoaneurysms of

the gastroduodenal or pancreaticoduodenal artery based on clinical and anatomical evaluations, preferring endovascular solutions whenever possible.

Good Practice Point (GPP) recommendation.

It is suggested to choose the type of elective treatment (open or endovascular) of pseudoaneurysms of the gastroduodenal or pancreaticoduodenal artery based on clinical, anatomical, multidisciplinary, and logistic evaluations.

Good Practice Point (GPP) recommendation.

Indications and treatment options: hepatic artery aneurysms

PICO 2.5.1 Clinical question

In patients with aneurysms/pseudoaneurysms of the hepatic artery, when is it justified to propose a surgical/endovascular treatment rather than medical therapy/follow-up alone to improve the outcomes?

Recommendations[33, 38, 76, 98, 117-122]

Emergency treatment is recommended in case of ruptured hepatic artery aneurysms/pseudoaneurysms. In case of symptomatic hepatic artery aneurysms, treatment is recommended in an urgent setting regardless of size.

Strong recommendation for (level of evidence 2+).

It is recommended to treat hepatic artery pseudoaneurysms as soon as possible, due to high rupture rates and mortality risk.

Strong recommendation for (level of evidence 2+).

Consider treatment in case of asymptomatic patients with hepatic artery aneurysms greater than 2 cm in diameter or demonstrated high increasing rates (0.5 cm/year), taking into account patients' comorbidities and life expectancy.

Conditional recommendation for (level of evidence 2-).

Consider treatment of hepatic artery aneurysms with diameters inferior to 2 cm in case of aneurysms of non-atherosclerotic origin or patients suffering from systemic pathology as vasculitis or collagen diseases, given a higher propensity for rupture.

Conditional recommendation for (level of evidence 2+).

PICO 2.5.2 Clinical question

In patients with an aneurysm/pseudoaneurysm of the hepatic artery, which intervention/procedure is preferable in terms of outcomes?

Recommendation[16, 123]

Consider an endovascular-first approach in patients with hepatic artery aneurysms/pseudoaneurysms if anatomically feasible (*e.g.*, the presence of anatomic conditions that allow the procedure and/or the possibility of maintaining arterial circulation to the liver).

Conditional recommendation for (level of evidence 2+).

PICO 2.5.3 Clinical question

In patients with extra-hepatic aneurysms/pseudoaneurysms suitable for repair, is it preferable to maintain hepatic arterial circulation over endovascular vessel ligation/closure to avoid hepatic necrosis?

Recommendation[16, 123-126]

In patients with extra-hepatic aneurysm/pseudoaneurysm, consider preserving hepatic arterial circulation rather than vessel ligation/endovascular occlusion to avoid hepatic necrosis.

Conditional recommendation for (level of evidence 2++).

PICO 2.5.4 Clinical question

In patients with intra-hepatic aneurysms/pseudoaneurysms suitable for repair, is it preferable the endovascular treatment over surgical lobe resection to preserve hepatic function?

Recommendations[16, 127]

In patients with intra-hepatic aneurysms/pseudoaneurysms consider the endovascular embolization of the affected arterial branch.

Conditional recommendation for (level of evidence 2++).

Consider lobe surgical resection in patients with giant intra-hepatic aneurysms/pseudoaneurysms (involving a whole segment or lobe), in order to avoid possible hepatic necrosis secondary to an endovascular approach.

Conditional recommendation for (level of evidence 2++).

Indications and treatment options: mesenteric arteries aneurysms

PICO 2.6.1 Clinical question

In patients with a mesenteric artery aneurysm/pseudoaneurysm, when is it justified to propose surgical/endovascular treatment compared to medical therapy/follow-up alone to improve the outcomes?

Recommendations[128-134]

Treatment is recommended for asymptomatic true mesenteric artery aneurysms with a diameter greater than 20 mm.

Strong recommendation for (level of evidence 2+).

Treatment is recommended in an urgent setting for symptomatic true mesenteric artery aneurysms, and in an emergent setting for ruptured true mesenteric artery aneurysms.

Strong recommendation for (level of evidence 2+).

Treatment is recommended regardless of size in case of mycotic and dissecting mesenteric artery aneurysms, as well as pseudoaneurysms.

Strong recommendation for (level of evidence 2+).

PICO 2.6.2 Clinical question

In patients with a mesenteric artery aneurysm/pseudoaneurysm, which intervention/procedure is preferable in terms of outcomes?

Recommendations[16, 92, 127, 130, 131, 134-143]

When technically feasible, the endovascular intervention is indicated rather than open surgery.

Strong recommendation for (level of evidence 2++).

It is suggested to leave the choice of the specific endovascular technique (bare stent and covered stent, embolization with coils, or combination of both) to be adopted to the discretion of the operator.

Good Practice Point (GPP) recommendation.

It is suggested to consider the use of flow-diverter stents to treat mesenteric artery aneurysms in selected cases.

Good Practice Point (GPP) recommendation.

Open surgery is suggested in case of unfavorable anatomy or failure of endovascular treatment.

Good Practice Point (GPP) recommendation.

In case of open surgery, consider intervention strategies that maintain the patency of the superior mesenteric artery and its branches (graft, bypass, etc.) rather than its ligation.

Conditional recommendation for (level of evidence 3).

Open surgery is suggested in case of mycotic mesenteric artery aneurysms.

Good Practice Point (GPP) recommendation.

Indications and treatment options: jejunal, ileal and colic arteries aneurysms

PICO 2.7.1 Clinical question

In a patient with an aneurysm/pseudoaneurysm of the jejunal, ileal or colic artery, when is surgical/endovascular treatment indicated versus medical therapy or watchful waiting to improve outcome?

Recommendation[144-149]

In the patient with aneurysm/pseudoaneurysm of the jejunal, ileal and colic arteries, it is suggested to propose a surgical/endovascular treatment in case of: all cases of colic aneurysms (ruptured, symptomatic and asymptomatic); jejunal or ileal aneurysms if ruptured or symptomatic or with a maximum diameter greater than 2 cm.

Good Practice Point (GPP) recommendation.

PICO 2.7.2 Clinical question

In a patient with an aneurysm/pseudoaneurysm of the jejunal, ileal or colic artery, which intervention/procedure is preferable in terms of outcome?

Recommendation[144, 146]

In patient with aneurysm/pseudoaneurysm of the jejunal, ileal or colic artery, an endovascular procedure is preferable to the surgical one both in election and in urgency/emergency setting, due to lower invasiveness and fewer immediate complications.

Good Practice Point (GPP) recommendation.

Indications and treatment options: isolated hypogastric artery aneurysms

PICO 2.8.1 Clinical question

In patients with an isolated hypogastric artery aneurysm, when the endovascular/surgical treatment strategy is justifiable, instead of the conservative management/follow-up, to improve the outcomes?

Recommendations[150-171]

Consider elective surgical/endovascular repair in those patients with asymptomatic isolated hypogastric artery aneurysms and acceptable surgical risk and life expectancy when the diameter is equal to or greater than 3 cm, or in case of demonstrated rapid growth.

Conditional recommendation for (level of evidence 3).

Emergency treatment is suggested in case of ruptured isolated hypogastric artery aneurysms.

Good Practice Point (GPP) recommendation.

Consider emergency treatment in case of symptomatic isolated hypogastric artery aneurysms.

Conditional recommendation for (level of evidence 3).

PICO 2.8.2 Clinical question

Which is the type of intervention/procedure to be preferred for patients with isolated hypogastric artery aneurysms?

Recommendation[153, 156, 157, 168, 169, 171]

In case of isolated hypogastric artery aneurysm, when it is feasible, the endovascular repair is recommended in both elective and urgent settings as the first option because of its early and mid-term outcomes.

Strong recommendation for (level of evidence 2++).

Medical therapy and follow-up

PICO 3.1 Clinical question

In patients with visceral or renal artery aneurysms who underwent corrective open/endovascular treatment, is CT angiography/magnetic resonance angiography superior to Doppler ultrasound (DUS) for follow-up surveillance?

Recommendations

In patients who underwent endovascular visceral and/or renal artery aneurysms treatment, it is suggested to perform a control CT angiography within 3 months and subsequently at 12 months from surgery, in order to identify possible endoleaks or sac volume increase that might lead to aneurysm rupture. If no complications develop at 12 months, it is suggested to extend follow-up time interval to 24-36 months.

Good Practice Point (GPP) recommendation.

In patients who underwent open surgical treatment for visceral and/or renal artery aneurysms, it is suggested to perform a control CT angiography within 3 months and subsequently at 12 months from surgery. If no complications develop at 12 months, no further diagnostic exams are deemed necessary.

Good Practice Point (GPP) recommendation.

In order to limit ionizing radiation exposure and iodinated contrast medium use in young patients and in patients with renal insufficiency (grade II-III), it is suggested to evaluate the use of alternative imaging methods, such as Magnetic Resonance angiography, DUS, Contrast-enhanced Ultrasound. In selected cases, non-contrast CT might be used to monitor aneurysm diameters.

Good Practice Point (GPP) recommendation.

PICO 3.2 Clinical question

In patients with visceral or renal artery aneurysms who did not undergo corrective treatment, is CT angiography/magnetic resonance angiography superior to Doppler ultrasound (DUS) for aneurysm dimensions surveillance?

Recommendations

In patients with untreated visceral and/or renal artery aneurysms, ultrasound surveillance at 12 months is suggested. If the aneurysm is not adequately assessable through ultrasound, CT angiography/Magnetic Resonance angiography is suggested. In case of demonstrated volumetric stability over time, surveillance at 24-36 months is suggested.

Good Practice Point (GPP) recommendation.

In order to limit ionizing radiation exposure and iodinated contrast medium use in young patients and in patients with renal insufficiency (grade II-III), it is suggested to evaluate the use of alternative imaging methods, such as magnetic resonance angiography, DUS, Contrast-enhanced ultrasound. In selected cases, non-contrast CT might be used to monitor aneurysm diameters.

Good Practice Point (GPP) recommendation.

PICO 3.3 Clinical question

In patients with visceral or renal artery aneurysms who did not undergo corrective treatment, is home medical therapy optimization indicated, compared to no therapy, to improve outcomes?

Recommendations[172-174]

In patients with untreated visceral and/or renal artery aneurysms of atherosclerotic nature, it is suggested to treat modifiable risk factors and optimize medical therapy in accordance with current guidelines on atherosclerosis.

Good Practice Point (GPP) recommendation.

In patients with untreated visceral and/or renal artery aneurysms of non-atherosclerotic non-inflammatory nature (degenerative, connective tissue disorders or congenital diseases), it is suggested to optimize antihypertensive therapy and stop smoking.

Good Practice Point (GPP) recommendation.

In patients with untreated visceral and/or renal artery aneurysms associated with connective tissue disorders, it is suggested to consider antiplatelet therapy.

Good Practice Point (GPP) recommendation.

In patients with an untreated visceral and/or renal artery inflammatory aneurysm, it is suggested the use of steroids and/or immunosuppressants to control inflammatory processes.

Good Practice Point (GPP) recommendation.

PICO 3.4 Clinical question

In patients with visceral or renal artery aneurysms who underwent corrective open/endovascular treatment, is home medical therapy optimization indicated, compared to no therapy, to improve outcomes?

Recommendations[172-174]

In patients who underwent open surgical or endovascular treatment of visceral and/or renal artery aneurysms of atherosclerotic nature, it is suggested to treat modifiable risk factors and optimize medical therapy in accordance with current guidelines on atherosclerosis.

Good Practice Point (GPP) recommendation.

In patients who underwent open surgical or endovascular treatment of visceral and/or renal artery aneurysms of non-atherosclerotic non-inflammatory nature (degenerative, connective tissue disorders or congenital diseases), it is suggested to optimize antihypertensive therapy and stop smoking.

Good Practice Point (GPP) recommendation.

In patients who underwent endovascular treatment of non-atherosclerotic non-inflammatory visceral and/or renal artery aneurysms, it is suggested to evaluate the use of short- or long-term antiplatelet therapy according to the type of device used.

Good Practice Point (GPP) recommendation.

In patients who underwent open surgical or endovascular treatment of visceral and/or renal artery aneurysms associated with connective tissue disorders, it is suggested to consider antiplatelet therapy.

Good Practice Point (GPP) recommendation.

In patients who underwent open surgical or endovascular treatment of visceral and/or renal artery inflammatory aneurysms, it is suggested the use of steroids and/or immunosuppressants to control inflammatory processes.

Good Practice Point (GPP) recommendation.

Discussion

Visceral artery aneurysms represent a relatively rare although clinically relevant pathology, with an incidence in the general population of up to 2%; they present in 22% of cases as clinical emergencies and 8.5% result in death 80. We found no RCTs evaluating clinical questions relative to this pathological condition, therefore the present Guidelines rely mostly on case-series, observational studies, and systematic reviews with or without meta-analysis of outcomes. Consequently, the panel did not give a high strength to most of the proposed recommendations, due to the generally low impact of the level of available evidence.

The accurate process of literature screening and selection made it possible to give 79 recommendations for the management of visceral and renal artery aneurysm disease.

Starting from the diagnosis, it is clear the superiority of CT angiography compared to DUS in terms of accuracy and anatomical characterization for procedural planning, even because the location of the aneurysm/pseudoaneurysm and a hostile abdomen make it often difficult to give appropriate measurements and details. Along with the latter diagnostic tools, it is important as well to mention the possible utilization of magnetic resonance imaging in case of young or chronic kidney disease patients.

It is not rare that a visceral aneurysm presents with concomitant aneurysmatic manifestations elsewhere in the body (4-44% other visceral arteries, 3-27% thoracoabdominal aorta and iliac arteries, 3-4% intracranial arteries),[57] even if there is currently no evidence in performing additional imaging studies but an accurate examination of images of the already scanned area. It is otherwise important to perform further screening tests, such as for fibromuscular dysplasia, to assess for underlying conditions which could be the reason for aneurysm manifestation.

Going to the indications, the panel performed separate analyses for each intra-abdominal major arterial district.

The threshold for renal artery aneurysms elective treatment has been set at 3 cm, which is in line with the Society for Vascular Surgery (SVS) Guidelines.[39] Current evidence demonstrates that there is no convenience in treating renal aneurysms between 2 and 3 cm because of the slow-growing natural history (0.06 to 0.6 mm per year) and not demonstrated risk of rupture under these dimensions.[17]

As concerning aneurysms of the splenic artery, the threshold for elective treatment has been set at 3 cm, which is in line with the SVS Guidelines,[39] and slightly higher than the ≥25 mm generically proposed by the European Society of Vascular Surgery (ESVS) for all asymptomatic true aneurysms of the visceral arteries;[175] in addition, the panel expressed a conditional recommendation for treatment of splenic artery aneurysms between 2 and 3 cm, reserving surveillance for patients with a low life expectancy or significant comorbidities and demonstrated stability of aneurysm dimensions over time.

The threshold for aneurysm treatment in case of celiac artery, hepatic artery, mesenteric arteries, jejunal and ileal arteries has been set at 2 cm, while colic and gastropancreaticoduodenal arteries aneurysms are recommended to be treated regardless of size. The latter recommendations

agree with the SVS Guidelines,[39] except for the mesenteric arteries (regardless of size for the superior mesenteric artery; no specific guideline for the inferior mesenteric artery); the differences between our indications and the SVS ones could lay to the fact that new evidence[128, 129] arouse in the last couple of years after SVS Guidelines publication, which we were able to include in our analyses.

Since it represents another important and crucial intra-abdominal artery and we did not focus on it in previously published Italian Guidelines dealing with aorto-iliac aneurysm disease,[6] our Guidelines gave recommendations for isolated hypogastric artery aneurysms as well. The treatment threshold has been set at 3 cm, and it has been lowered compared to European ESVS Guidelines on the topic (3.5 cm),[176] according to recently published outcomes of a meta-analysis specifically looking at just isolated hypogastric artery aneurysms.[171]

Lastly, in accordance with International Guidelines,[39, 175] the panel agreed on the treatment regardless of dimensions in case of symptomatic, ruptured and rapidly increasing aneurysms, as well as all pseudoaneurysms; it is still debatable whether and at which dimensions it is convenient to treat women of childbearing age, and since the evidence is still not clear the panel suggested to consider treatment under dimensional threshold in case of demonstrated rapid growth.

Referring to treatment options, it emerged that the treatment of all aneurysms of the visceral and renal arteries is essentially achievable, with satisfactory results, both trough endovascular solutions and open surgery; the preference between the two must take into account the anatomical feasibility for an endovascular intervention and patients' fitness for open surgery, as well as logistic and multidisciplinary considerations which might direction the treatment strategy.

However, in view of the less invasiveness and fewer complications, endovascular solutions have been confirmed to be the preferred method for the treatment of these aneurysms, and for the same reasons the panel suggested an endovascular-first approach for most of the intra-abdominal arterial districts being addressed.

Concluding the management pathway of visceral and renal artery aneurysm disease, the recommendations suggested for the follow-up and medical therapy of patients both treated (surgically or endovascularly) and not treated (aneurysm surveillance only) were all Good Practice Points (GPP) formulated after panel discussion, since authors were not able to find adequate quality literature on the topic.

Conclusions

These Guidelines are intended to outline the correct management of patients affected by visceral and renal artery disease, 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 for additional studies in this field, with a more relevant methodology, to address questions which are still open.

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

Authors' contributions
Carlo Pratesi, Davide Esposito, Massimiliano Orso, and Maurizio Cariati have given substantial contributions to the conception and the design of the manuscript; all authors contributed to acquisition, analysis and interpretation of the data. All authors have participated to drafting the manuscript, Carlo Pratesi and Maurizio Cariati revised it critically. All authors read and approved the final version of the manuscript.

Group author members
Italian Guidelines for Vascular and Endovascular Surgery Collaborators. Chair: Maurizio CARIATI; Carlo PRATESI. *Scientific Technical Committee*: Maurizio CARIATI; Romeo MARTINI; Claudio NOVALI; Carlo PRATESI; Augusto ZANINELLI. *Panel of Experts - authors*: Antonio L. ANNESE; Paolo BAGGI; Raffaello BELLOSTA; Claudio BIANCHINI MASSONI; Stefano BONARDELLI; Serena CARRIERO; Rosa CERVELLI; Emiliano CHISCI; Roberto CIONI; Fabio CORVINO; Francesco DE COBELLI; Davide ESPOSITO; Fabrizio FANELLI; Aaron T. FARGION; Marco FEMIA; Antonio FREYRIE; Andrea GAGGIANO; Enrico GALLITTO; Stefano GENNAI; Emanuela GIAMPALMA; Francesco GIURAZZA; Franco GREGO; Giorgia GUAZZAROTTI; Anna M. IERARDI; Andrea L. KAHLBERG; Daniele MASCIA; Luca MEZZETTO; Stefano MICHELAGNOLI; Floriana NARDELLI; Raffaella NIOLA; Massimo LENTI; Orsola PERRONE; Filippo PIACENTINO; Gabriele PIFFARETTI; Raffaele PULLI; Gino PUNTEL; Giovanni PUPPINI; Denis ROSSATO; Michele ROSSI; Roberto SILINGARDI; Pasqualino SIRIGNANO; Francesco SQUIZZATO; Marcello Andrea TIPALDI; Massimo VENTURINI; Gian F. VERALDI; Antonio VIZZUSO. *Methodological Group*: Massimiliano ORSO (Reference Methodologist); Sara ALLIEVI; Luca ATTISANI; Gianluigi FINO; Francesca GHIRARDINI; Paola MANZO; Mattia MIGLIARI; Stephanie STEIDLER. *External Reviewers*: Vittorio MIELE; Maurizio TAURINO.

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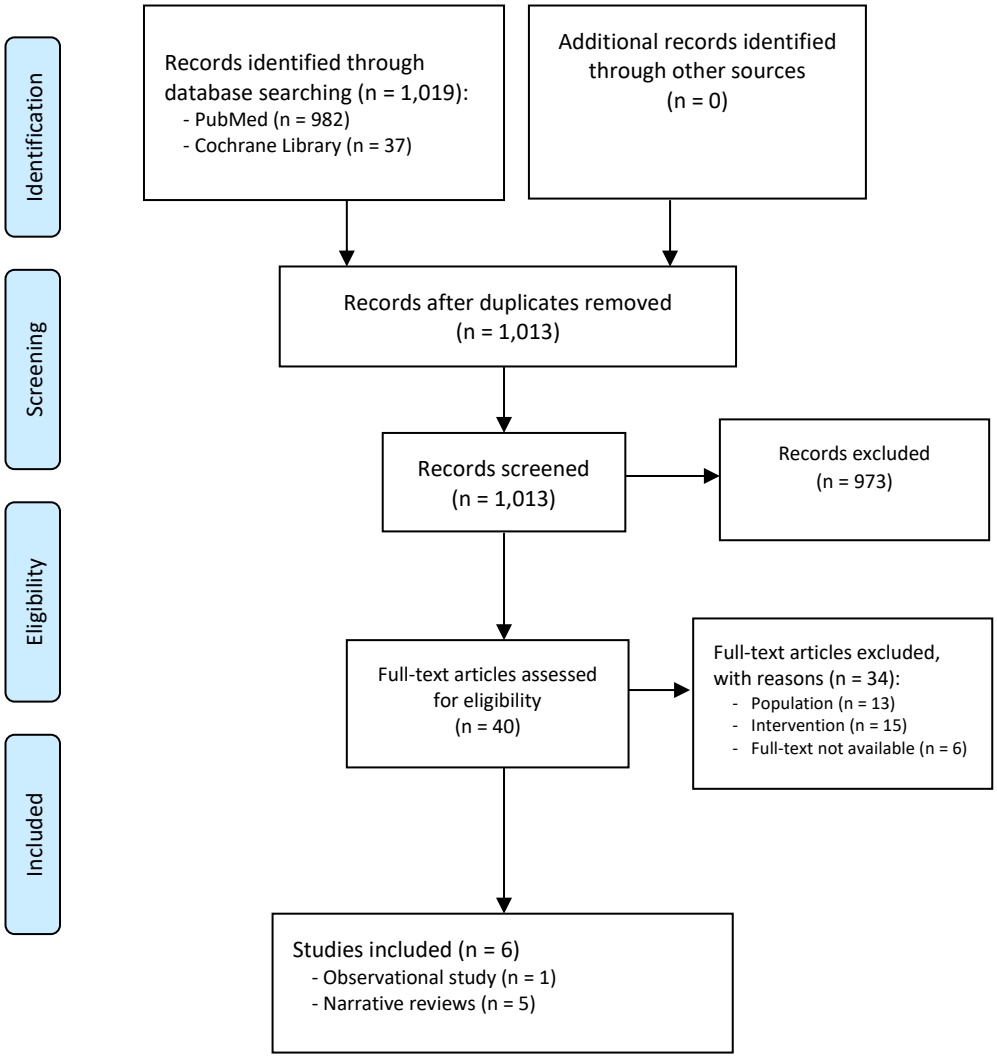
SUPPLEMENTARY DIGITAL MATERIAL 1

Literature search strategies and PRISMA Flow Diagrams

Supplementary Table I.—PICO 1 search strategies.

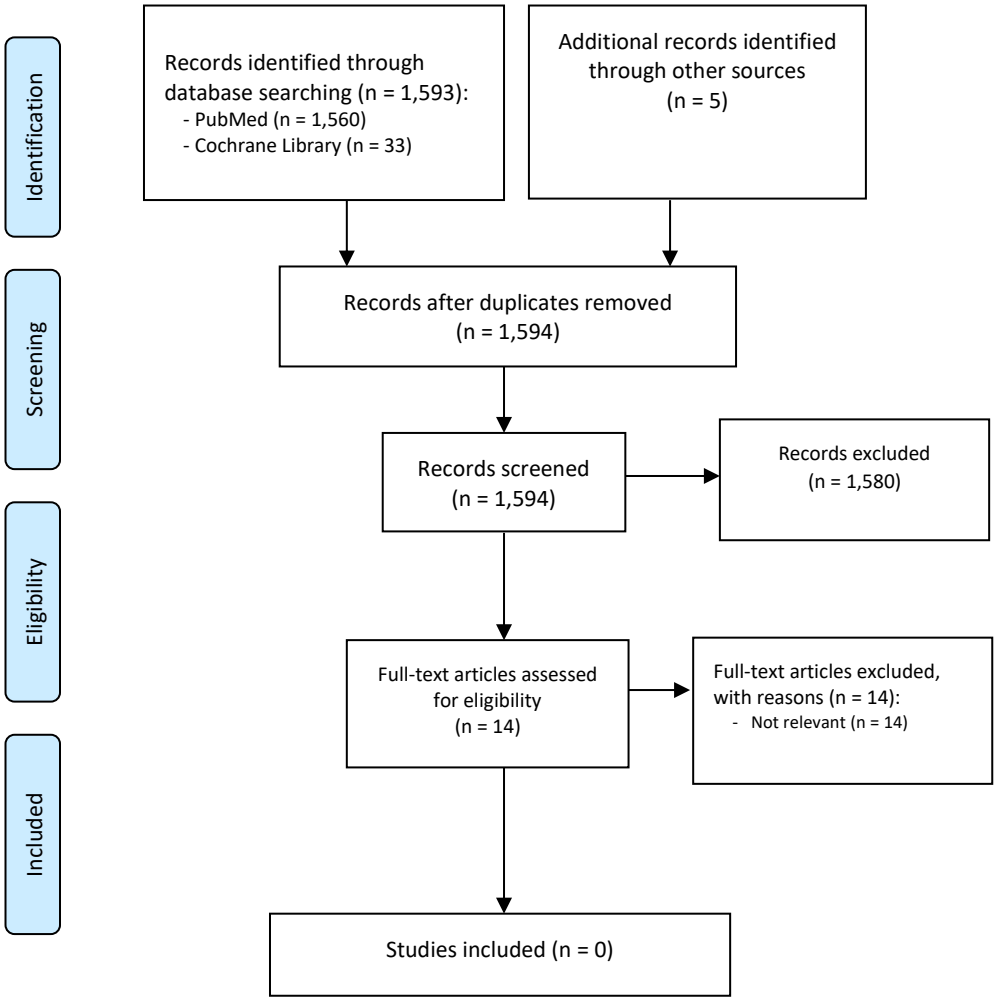
PubMed, searched on 01/06/2022		
Search	Query	Results
#1	((visceral OR renal OR splenic OR lienal OR hepatic OR celiac OR coeliac OR gastric OR gastroepiploic OR mesenteric OR jejunal OR ileal OR iliac OR ilial OR colic OR pancreaticoduodenal OR gastroduodenal OR pancreatico-duodenal OR gastro-duodenal OR hypogastric OR "internal iliac") AND (artery OR arteries)) OR "arteria coeliaca" OR "arteria gastrica" OR "arteria gastroduodenalis" OR "arteria gastroepiploica" OR "arteria hepatica" OR "arteria lienalis" OR "arteria mesenterica" OR "arteria renalis" OR "celiac axis" OR "celiac trunk" OR "coeliac axis" OR "coeliac trunk" OR "truncus celiacus" OR "truncus coeliacus"	196,368
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms	181,556
#3	diagnosis	11,042,488
#4	CT angiography OR computed tomography OR computed tomography angiography	633,713
#5	#1 AND #2 AND #3 AND #4	6,577
#6	#1 AND #2 AND #3 AND #4 Filters: Clinical Trial, Comparative Study, Controlled Clinical Trial, Meta-Analysis, Observational Study, Randomized Controlled Trial, Review, Systematic Review, English, Italian	982
Cochrane Library, searched on 01/06/2022		
Search	Query	Results
#1	((visceral OR renal OR splenic OR lienal OR hepatic OR celiac OR coeliac OR gastric OR gastroepiploic OR mesenteric OR jejunal OR ileal OR iliac OR ilial OR colic OR pancreaticoduodenal OR gastroduodenal OR pancreatico-duodenal OR gastro-duodenal OR hypogastric OR "internal iliac") AND (artery OR arteries)) OR "arteria coeliaca" OR "arteria gastrica" OR "arteria gastroduodenalis" OR "arteria gastroepiploica" OR "arteria hepatica" OR "arteria lienalis" OR "arteria mesenterica" OR "arteria renalis" OR "celiac axis" OR "celiac trunk" OR "coeliac axis" OR "coeliac trunk" OR "truncus celiacus" OR "truncus coeliacus" (Word variations have been searched)	12,849
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms (Word variations have been searched)	5,592
#3	diagnosis (Word variations have been searched)	219,199
#4	CT angiography OR computed tomography OR computed tomography angiography (Word variations have been searched)	25,749
#5	#1 AND #2 AND #3 AND #4 in Cochrane Reviews and Trials	37



Supplementary Figure 1.—PICO 1 PRISMA flow diagram.

Supplementary Table II.—PICO 1 search strategies.

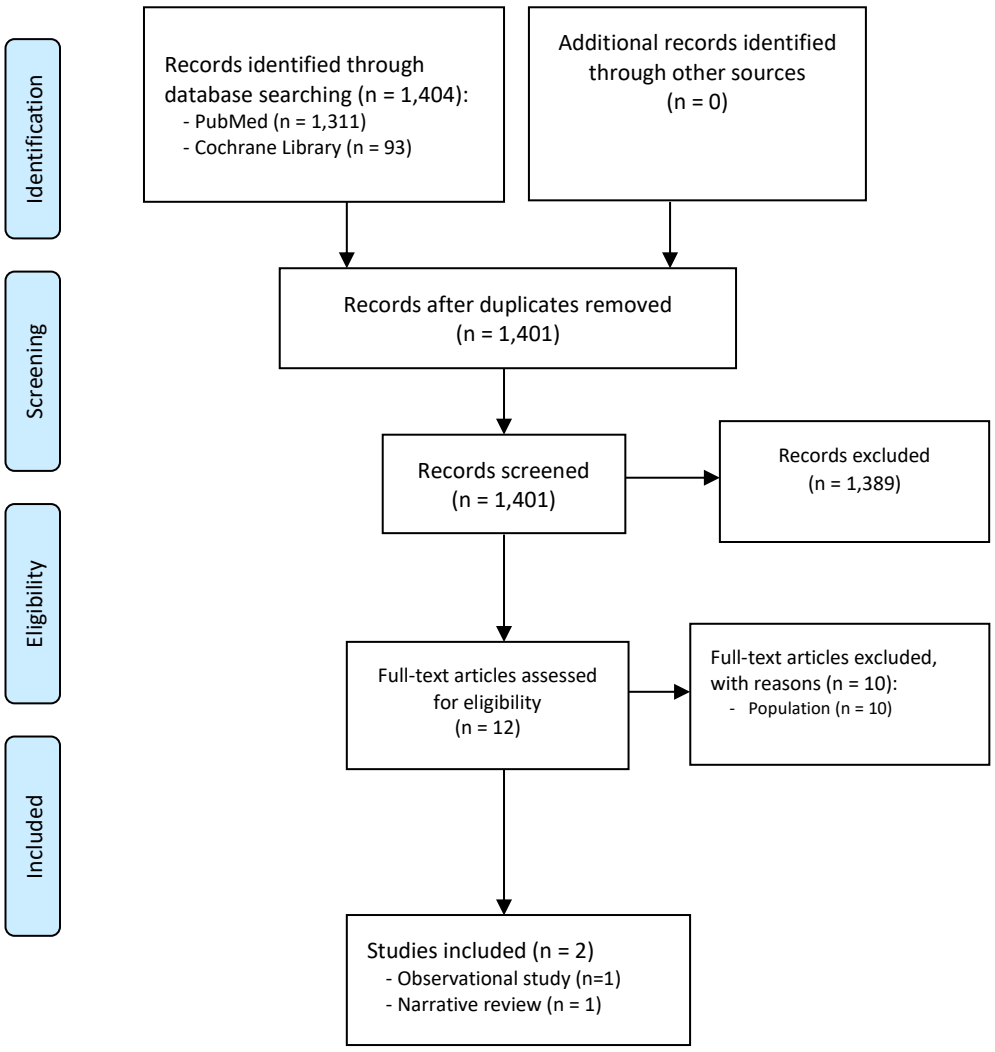
PubMed, searched on 16/05/2022		
Search	Query	Results
#1	((visceral OR renal OR splenic OR lienal OR hepatic OR celiac OR coeliac OR gastric OR gastroepiploic OR mesenteric OR jejunal OR ileal OR iliac OR ilial OR colic OR pancreaticoduodenal OR gastroduodenal OR pancreatico-duodenal OR gastro-duodenal OR hypogastric OR "internal iliac") AND (artery OR arteries)) OR "arteria coeliaca" OR "arteria gastrica" OR "arteria gastroduodenalis" OR "arteria gastroepiploica" OR "arteria hepatica" OR "arteria lienalis" OR "arteria mesenterica" OR "arteria renalis" OR "celiac axis" OR "celiac trunk" OR "coeliac axis" OR "coeliac trunk" OR "truncus celiacus" OR "truncus coeliacus"	196,307
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms	181,278
#3	"Computed Tomography Angiography"[Mesh] OR computed tomography angiography OR "Magnetic Resonance Angiography"[Mesh] OR magnetic resonance angiography OR "Ultrasonography, Doppler, Duplex"[Mesh] OR ultrasonography doppler duplex OR "Angiography, Digital Subtraction"[Mesh] OR angiography digital subtraction	138,065
#4	screening OR prevention	7,980,053
#5	#1 AND #2 AND #3 AND #4	3,838
#6	#5 NOT ("case report"[Title] OR "case reports"[Title] OR "case reports"[Publication Type] OR "letter"[Publication Type] OR "editorial"[Publication Type] OR "comment"[Publication Type]) Filters: English, Italian	1,560
Cochrane Library, searched on 16/05/2022		
Search	Query	Results
#1	((visceral OR renal OR splenic OR lienal OR hepatic OR celiac OR coeliac OR gastric OR gastroepiploic OR mesenteric OR jejunal OR ileal OR iliac OR ilial OR colic OR pancreaticoduodenal OR gastroduodenal OR pancreatico-duodenal OR gastro-duodenal OR hypogastric OR "internal iliac") AND (artery OR arteries)) OR "arteria coeliaca" OR "arteria gastrica" OR "arteria gastroduodenalis" OR "arteria gastroepiploica" OR "arteria hepatica" OR "arteria lienalis" OR "arteria mesenterica" OR "arteria renalis" OR "celiac axis" OR "celiac trunk" OR "coeliac axis" OR "coeliac trunk" OR "truncus celiacus" OR "truncus coeliacus"	12,803
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms	5,567
#3	computed tomography angiography OR magnetic resonance angiography OR ultrasonography doppler duplex OR angiography digital subtraction	4,608
#4	screening OR prevention	332,959
#5	#1 AND #2 AND #3 AND #4	33



Supplementary Figure 2.—PICO 2 PRISMA flow diagram.

Supplementary Table III.—PICO 3 search strategies.

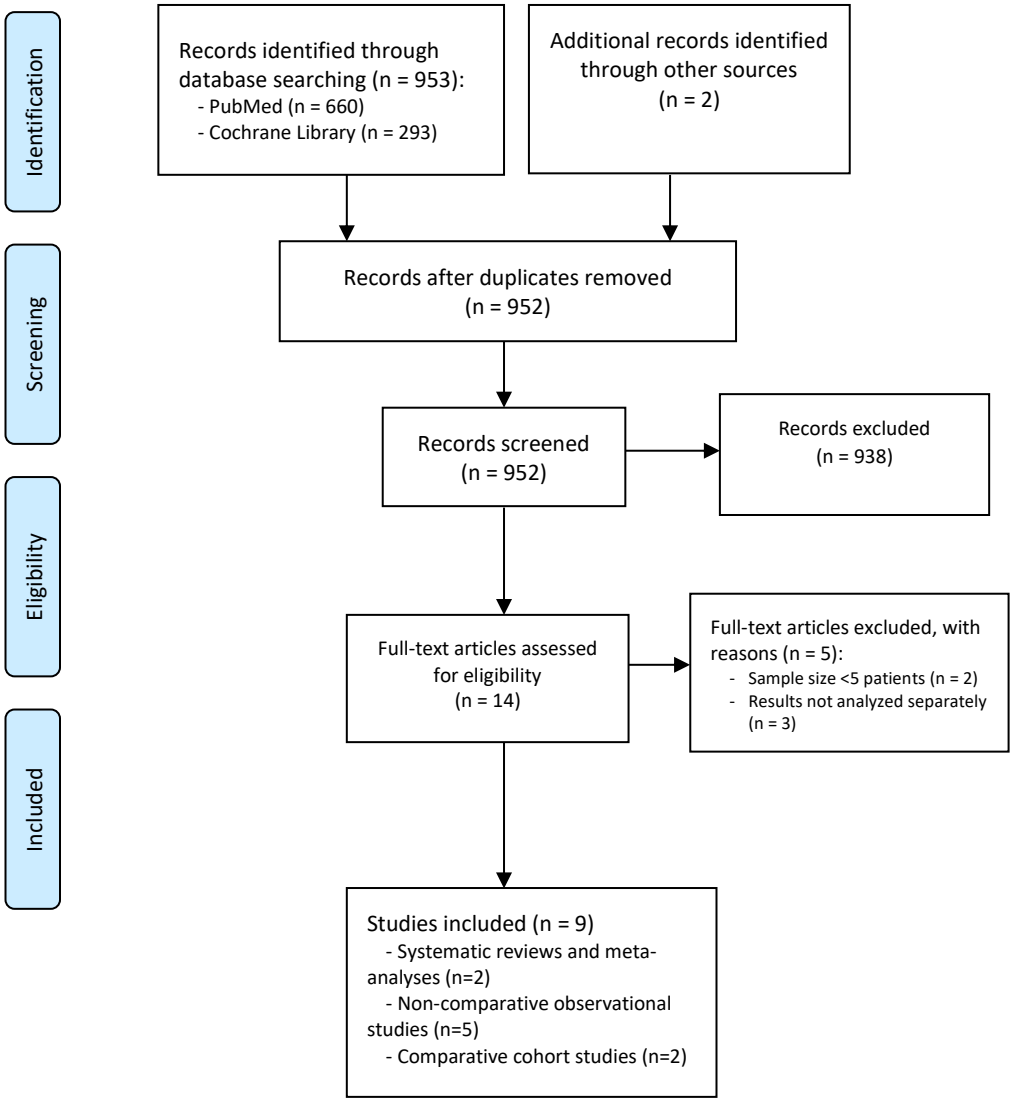
PubMed, searched on 30/05/2022		
Search	Query	Results
#1	((visceral OR renal OR splenic OR lienal OR hepatic OR celiac OR coeliac OR gastric OR gastroepiploic OR mesenteric OR jejunal OR ileal OR iliac OR ilial OR colic OR pancreaticoduodenal OR gastroduodenal OR pancreatico-duodenal OR gastro-duodenal OR hypogastric OR "internal iliac") AND (artery OR arteries)) OR "arteria coeliaca" OR "arteria gastrica" OR "arteria gastroduodenalis" OR "arteria gastroepiploica" OR "arteria hepatica" OR "arteria lienalis" OR "arteria mesenterica" OR "arteria renalis" OR "celiac axis" OR "celiac trunk" OR "coeliac axis" OR "coeliac trunk" OR "truncus celiacus" OR "truncus coeliacus"	196,343
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms	181,509
#3	associated disease OR concomitant disease OR comorbidity	4,544,676
#4	screening OR prevention	7,995,876
#5	#1 AND #2 AND #3 AND #4	8,398
#6	#1 AND #2 AND #3 AND #4 Filters: Clinical Trial, Comparative Study, Controlled Clinical Trial, Meta-Analysis, Observational Study, Randomized Controlled Trial, Review, Systematic Review, English, Italian	1,311
Cochrane Library, searched on 30/05/2022		
Search	Query	Results
#1	((visceral OR renal OR splenic OR lienal OR hepatic OR celiac OR coeliac OR gastric OR gastroepiploic OR mesenteric OR jejunal OR ileal OR iliac OR ilial OR colic OR pancreaticoduodenal OR gastroduodenal OR pancreatico-duodenal OR gastro-duodenal OR hypogastric OR "internal iliac") AND (artery OR arteries)) OR "arteria coeliaca" OR "arteria gastrica" OR "arteria gastroduodenalis" OR "arteria gastroepiploica" OR "arteria hepatica" OR "arteria lienalis" OR "arteria mesenterica" OR "arteria renalis" OR "celiac axis" OR "celiac trunk" OR "coeliac axis" OR "coeliac trunk" OR "truncus celiacus" OR "truncus coeliacus" (Word variations have been searched)	12,804
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms (Word variations have been searched)	5,567
#3	associated disease OR concomitant disease OR comorbidity (Word variations have been searched)	164,355
#4	screening OR prevention (Word variations have been searched)	332,968
#5	#1 AND #2 AND #3 AND #4 in Cochrane Reviews and Trials	93



Supplementary Figure 3.—PICO 3 PRISMA flow diagram.

Supplementary Table IV.—PICO 1 and 2 search strategies on renal artery aneurysms.

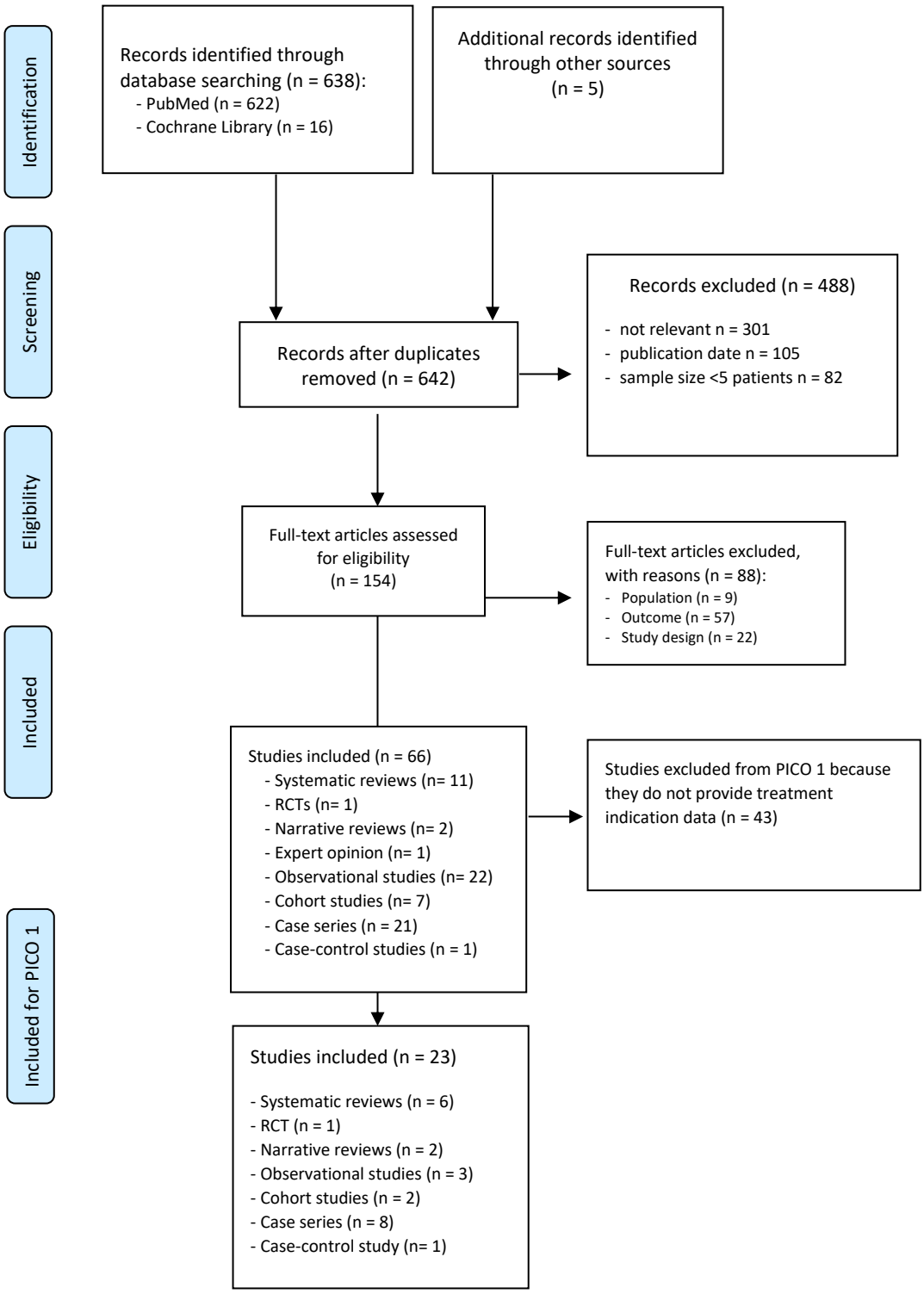
PubMed, searched on 17/05/2022		
Search	Query	Results
#1	"visceral artery"[Title] OR "visceral arteries"[Title] OR "renal artery"[Title] OR "renal arteries"[Title] OR "arteria renalis"[Title] OR (("arterias"[All Fields] OR "arteries"[MeSH Terms] OR "arteries"[All Fields] OR "arteria"[All Fields] OR "arteriae"[All Fields]) AND "renis"[Title])	9,585
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms	181,289
#3	procedure OR procedures OR surgery OR surgeries OR technique OR techniques OR operation OR operations OR intervention OR interventions OR therapy OR therapies OR management OR treatment OR treatments OR correction OR corrections OR repair OR repairs OR revascularization OR revascularizations OR reimplantation OR reimplantations OR resection OR resections OR embolization OR embolizations OR aneurysmectomy OR aneurysmectomies OR bypass OR bypasses OR graft OR grafts OR prosthesis OR prostheses OR endovascular OR hybrid OR hybrids	21,197,583
#4	#1 AND #2 AND #3	1,785
#5	#4 NOT ("case report" OR "case reports" OR "case reports"[Publication Type] OR "letter"[Publication Type] OR "editorial"[Publication Type] OR "comment"[Publication Type]) Filters: English, Italian	660
Cochrane Library, searched on 17/05/2022		
Search	Query	Results
#1	visceral artery OR visceral arteries OR renal artery OR renal arteries OR arteria renalis OR arteria renis	5,166
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms	5,011
#3	procedure OR procedures OR surgery OR surgeries OR technique OR techniques OR operation OR operations OR intervention OR interventions OR therapy OR therapies OR management OR treatment OR treatments OR correction OR corrections OR repair OR repairs OR revascularization OR revascularizations OR reimplantation OR reimplantations OR resection OR resections OR embolization OR embolizations OR aneurysmectomy OR aneurysmectomies OR bypass OR bypasses OR graft OR grafts OR prosthesis OR prostheses OR endovascular OR hybrid OR hybrids	1,453,624
#4	#1 AND #2 AND #3	293



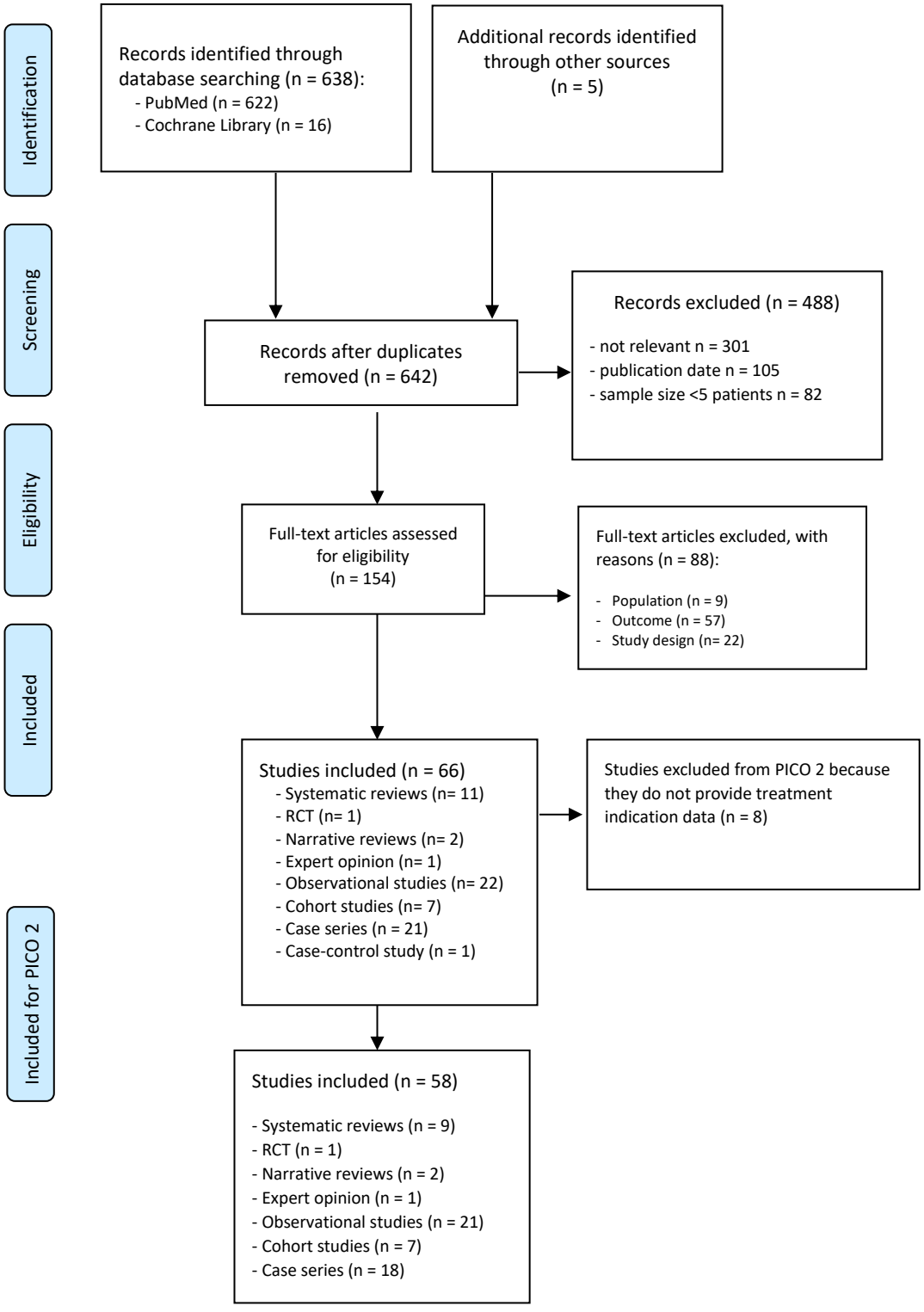
Supplementary Figure 4.—PICO 1 and 2 PRISMA flow diagram on renal artery aneurysms.

Supplementary Table V.—PICO 1 and 2 search strategies on splenic artery aneurysms.

PubMed, searched on 24/05/2022		
Search	Query	Results
#1	splenic artery OR lienal artery OR (spleen AND artery)	11,791
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms	181,414
#3	procedure OR procedures OR surgery OR surgeries OR technique OR techniques OR operation OR operations OR intervention OR interventions OR therapy OR therapies OR management OR treatment OR treatments OR correction OR corrections OR repair OR repairs OR revascularization OR revascularizations OR reimplantation OR resection OR resections OR aneurysmectomy OR bypass OR graft OR grafts OR prosthesis OR prostheses OR endovascular OR hybrid OR hybrids	21,190,840
#4	#1 AND #2 AND #3	2,012
#5	#4 NOT ("case report" OR "case reports" OR "case reports"[Publication Type] OR "letter"[Publication Type] OR "editorial"[Publication Type] OR "comment"[Publication Type]) Filters: English, Italian	622
Cochrane Library, searched on 24/05/2022		
Search	Query	Results
#1	splenic artery OR lienal artery OR (spleen AND artery)	311
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms	5,567
#3	procedure OR procedures OR surgery OR surgeries OR technique OR techniques OR operation OR operations OR intervention OR interventions OR therapy OR therapies OR management OR treatment OR treatments OR correction OR corrections OR repair OR repairs OR revascularization OR revascularizations OR reimplantation OR resection OR resections OR aneurysmectomy OR bypass OR graft OR grafts OR prosthesis OR prostheses OR endovascular OR hybrid OR hybrids	1,469,946
#4	#1 AND #2 AND #3 in Cochrane Reviews and Trials	16



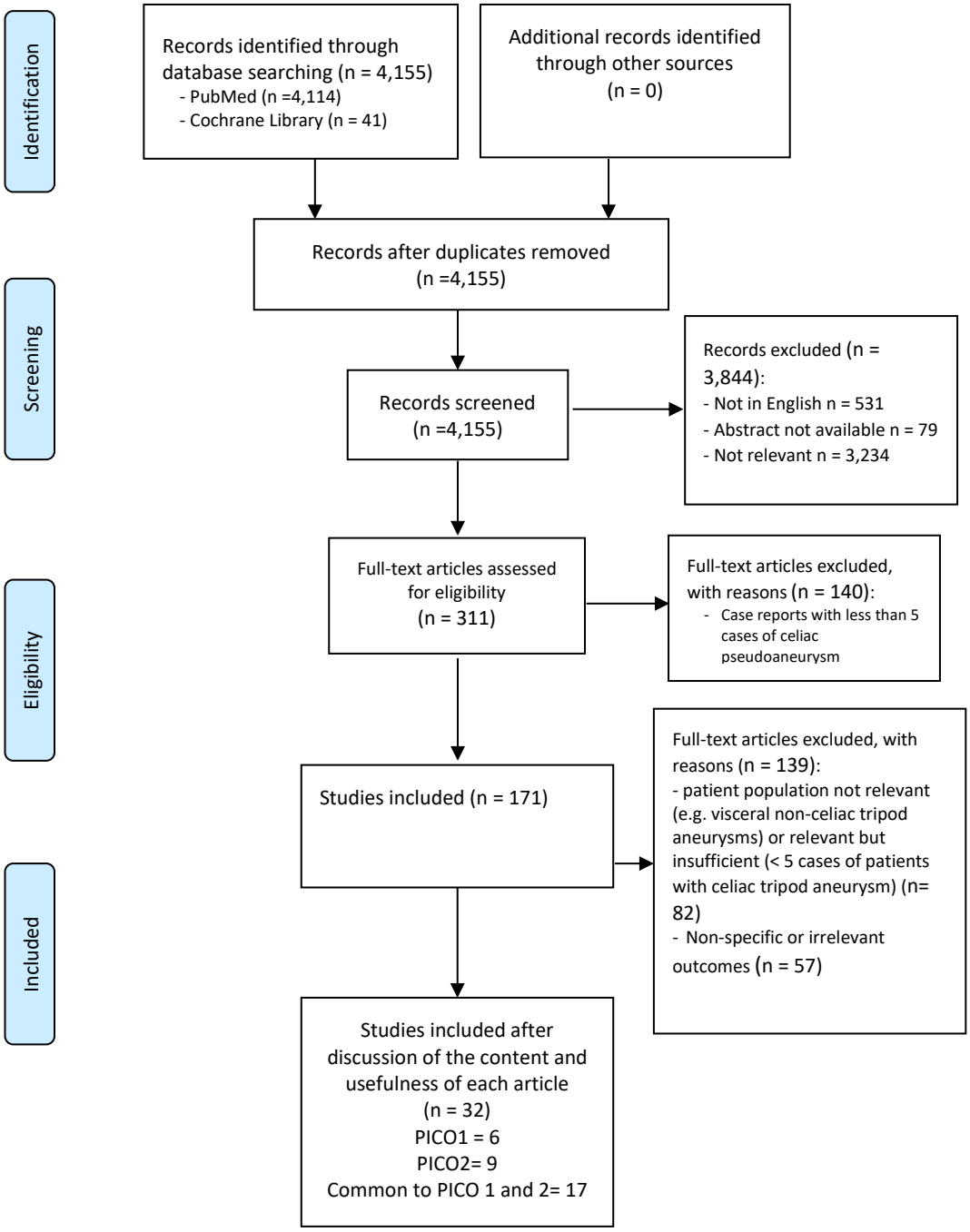
Supplementary Figure 5.—PICO 1 PRISMA flow diagram on splenic artery aneurysms.



Supplementary Figure 6.—PICO 2 PRISMA flow diagram on splenic artery aneurysms.

Supplementary Table VI.—PICO 1 and 2 search strategies on celiac artery aneurysms.

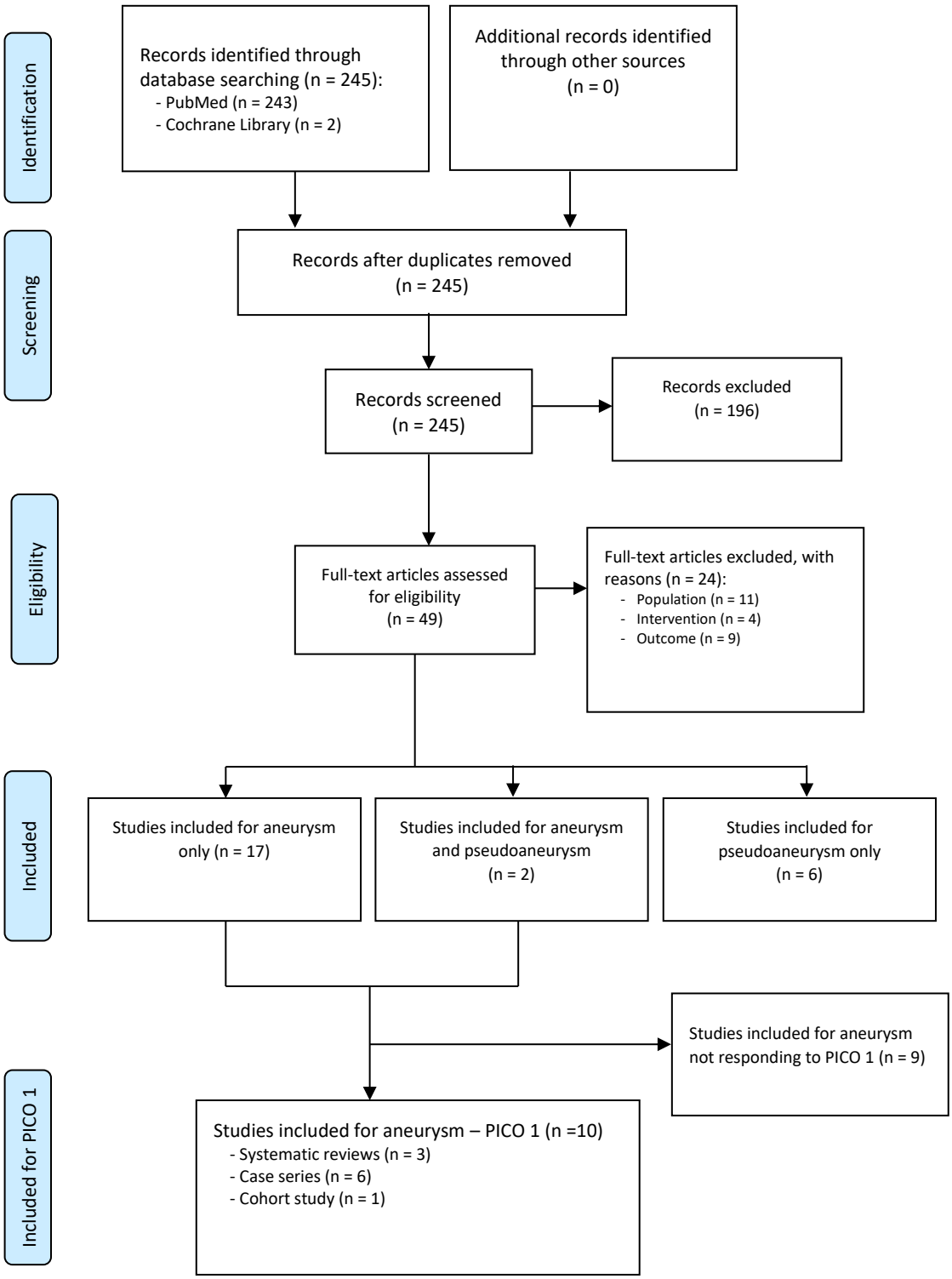
PubMed, searched on 02/05/2022		
Search	Query	Results
#1	celiac artery OR coeliac artery OR celiac trunk OR truncus coeliacus OR celiac tripod OR coeliac tripod OR visceral	98,885
#2	endovascular OR open OR surgery OR surgical treatment OR emergent treatment OR urgent treatment OR elective treatment OR percutaneous OR stent OR stenting OR embolization OR coil OR coiling	6,547,722
#3	aneurysm OR pseudoaneurysm	180,208
#4	#1 AND #2 AND #3	4,114
Cochrane Library, searched on 19/05/2022		
Search	Query	Results
#1	celiac artery OR coeliac artery OR celiac trunk OR truncus coeliacus OR celiac tripod OR coeliac tripod OR visceral	228 reviews 47 protocols 6,778 trials 1 editorial 14 clinical answers
#2	endovascular OR open OR surgery OR surgical treatment OR emergent treatment OR urgent treatment OR elective treatment OR percutaneous OR stent OR stenting OR embolization OR coil OR coiling	8,419 reviews; 1,511 protocols; 454,171 trials; 84 editorials; 22 special collections; 2,884 clinical answers
#3	aneurysm OR pseudoaneurysm	294 reviews; 46 protocols; 5,052 trials; 2 editorials; 33 clinical answers
#4	#1 AND #2 AND #3	14 reviews 2 protocols 25 trials



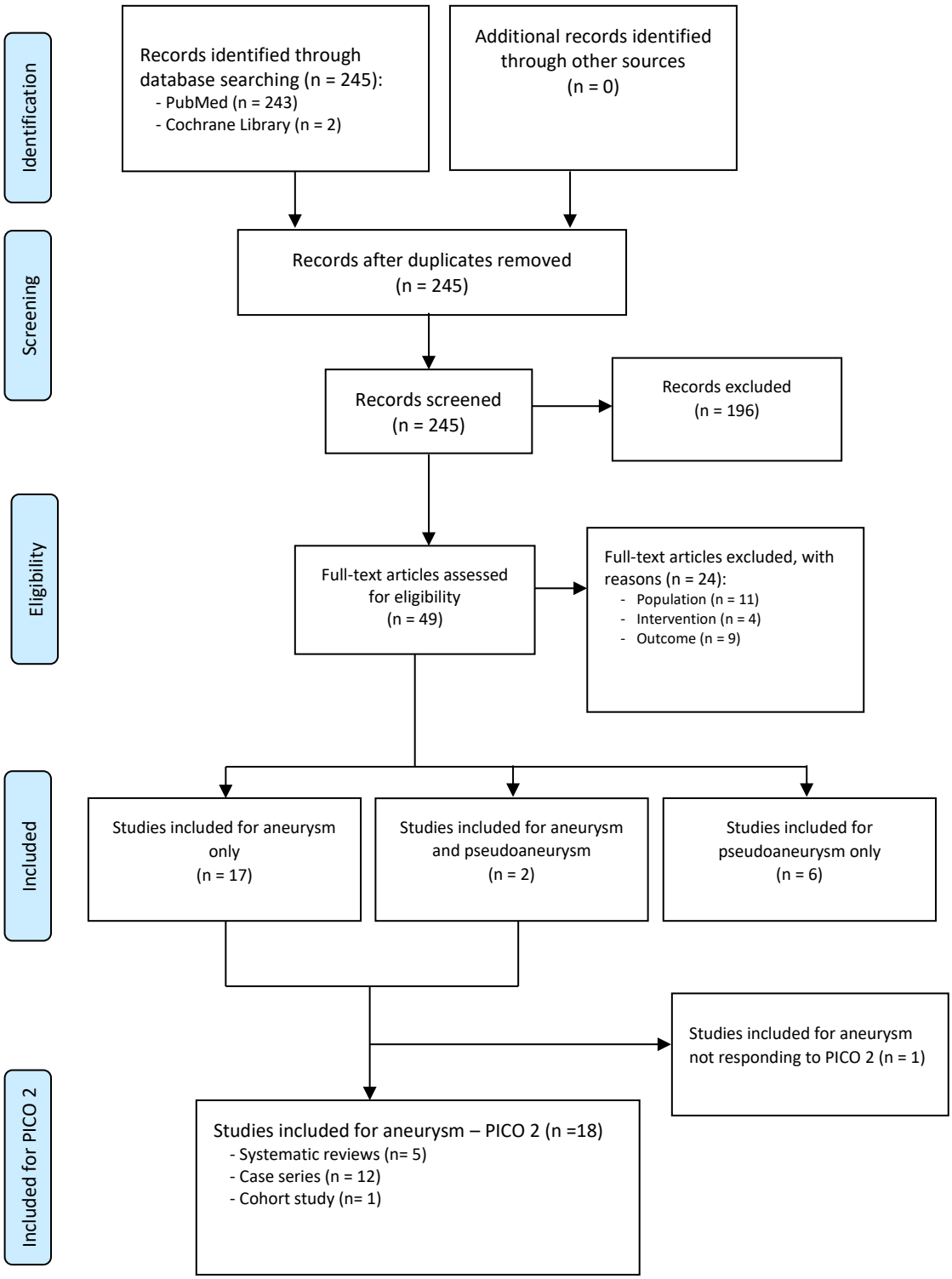
Supplementary Figure 7.—PICO 1 and 2 PRISMA flow diagram on celiac artery aneurysms.

Supplementary Table VII.—Search strategies on gastropancreaticoduodenal artery aneurysms (PICO 1 and 2) and pseudoaneurysms (PICO 3 and 4).

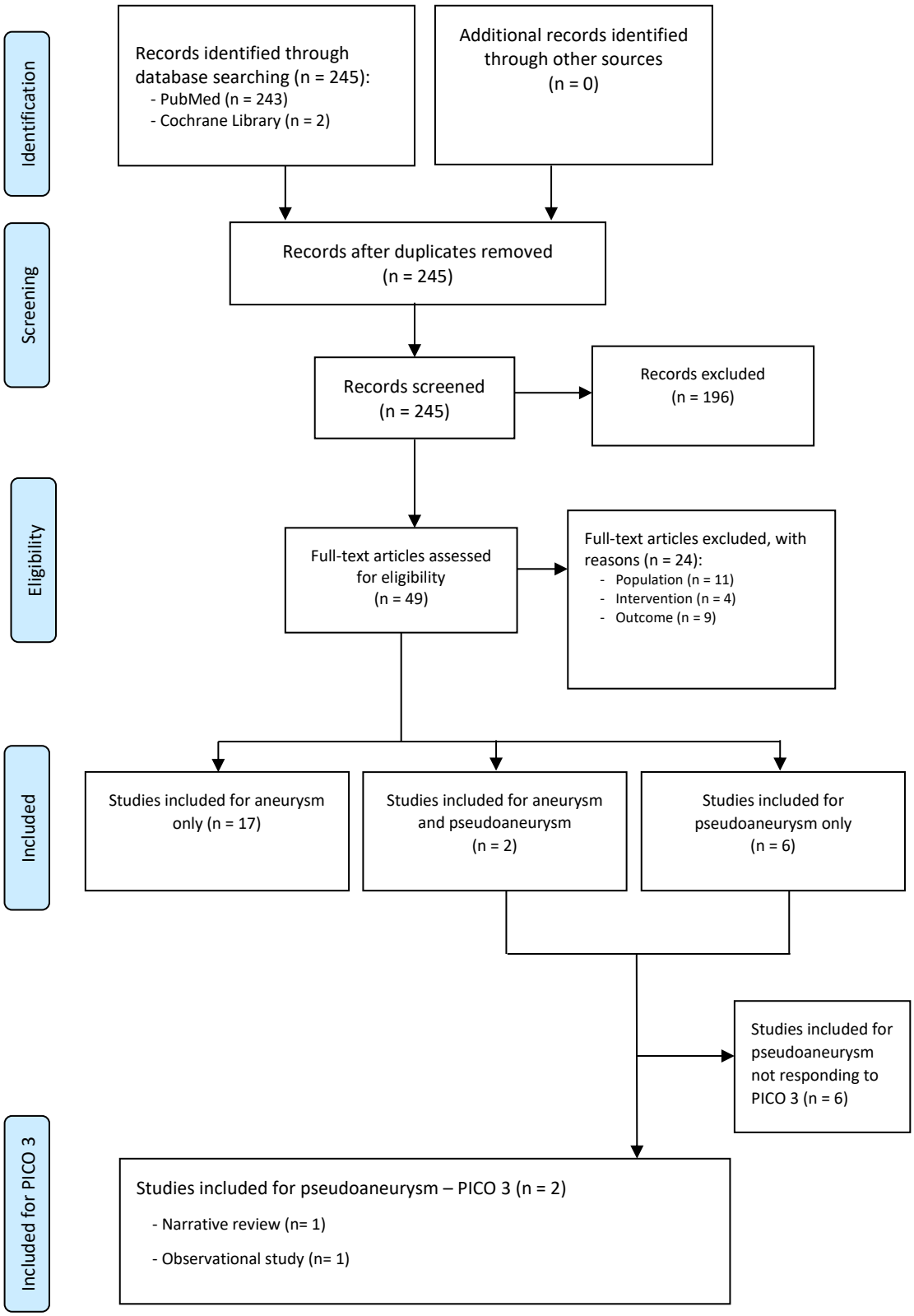
PubMed, searched on 23/05/2022		
Search	Query	Results
#1	gastroduodenal OR gastro-duodenal OR pancreaticoduodenal OR pancreatico-duodenal	15,547
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms	181,390
#3	procedure OR procedures OR surgery OR surgeries OR technique OR techniques OR operation OR operations OR intervention OR interventions OR therapy OR therapies OR management OR treatment OR treatments OR correction OR corrections OR repair OR repairs OR revascularization OR revascularizations OR reimplantation OR resection OR resections OR aneurysmectomy OR bypass OR graft OR grafts OR prosthesis OR prostheses OR endovascular OR hybrid OR hybrids	21,187,741
#4	#1 AND #2 AND #3	828
#5	#4 NOT ("case report"[Title] OR "case reports"[Title] OR "case reports"[Publication Type] OR "letter"[Publication Type] OR "editorial"[Publication Type] OR "comment"[Publication Type]) Filters: English, Italian	243
Cochrane Library, searched on 23/05/2022		
Search	Query	Results
#1	gastroduodenal OR gastro-duodenal OR pancreaticoduodenal OR pancreatico-duodenal	1,159
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms	5,567
#3	procedure OR procedures OR surgery OR surgeries OR technique OR techniques OR operation OR operations OR intervention OR interventions OR therapy OR therapies OR management OR treatment OR treatments OR correction OR corrections OR repair OR repairs OR revascularization OR revascularizations OR reimplantation OR resection OR resections OR aneurysmectomy OR bypass OR graft OR grafts OR prosthesis OR prostheses OR endovascular OR hybrid OR hybrids	1,469,943
#4	#1 AND #2 AND #3 in Cochrane Reviews and Trials	2



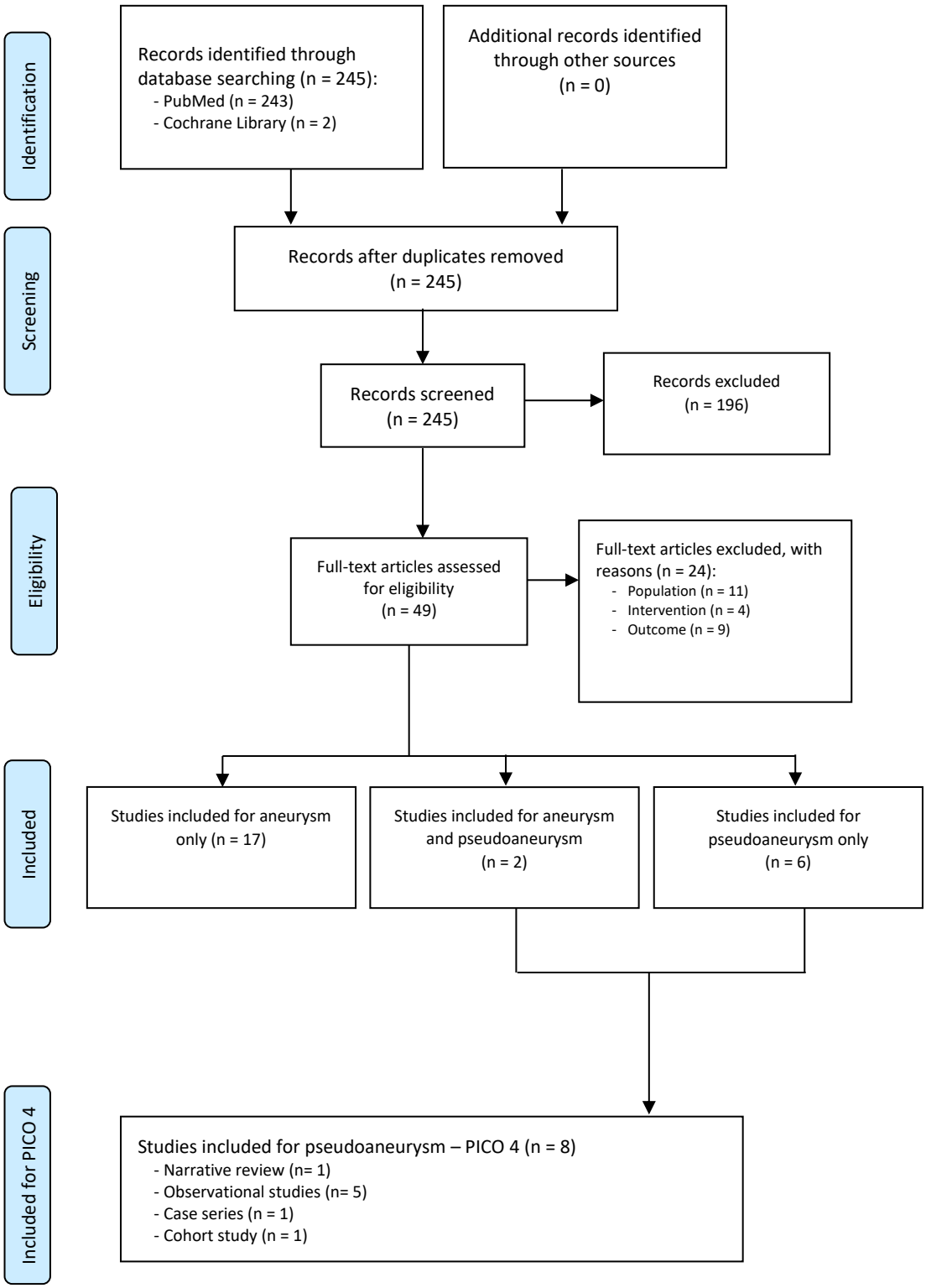
Supplementary Figure 8.—PICO 1 PRISMA flow diagram on gastropancreaticoduodenal artery aneurysms.



Supplementary Figure 9.—PICO 2 PRISMA flow diagram on gastropancreaticoduodenal artery aneurysms.



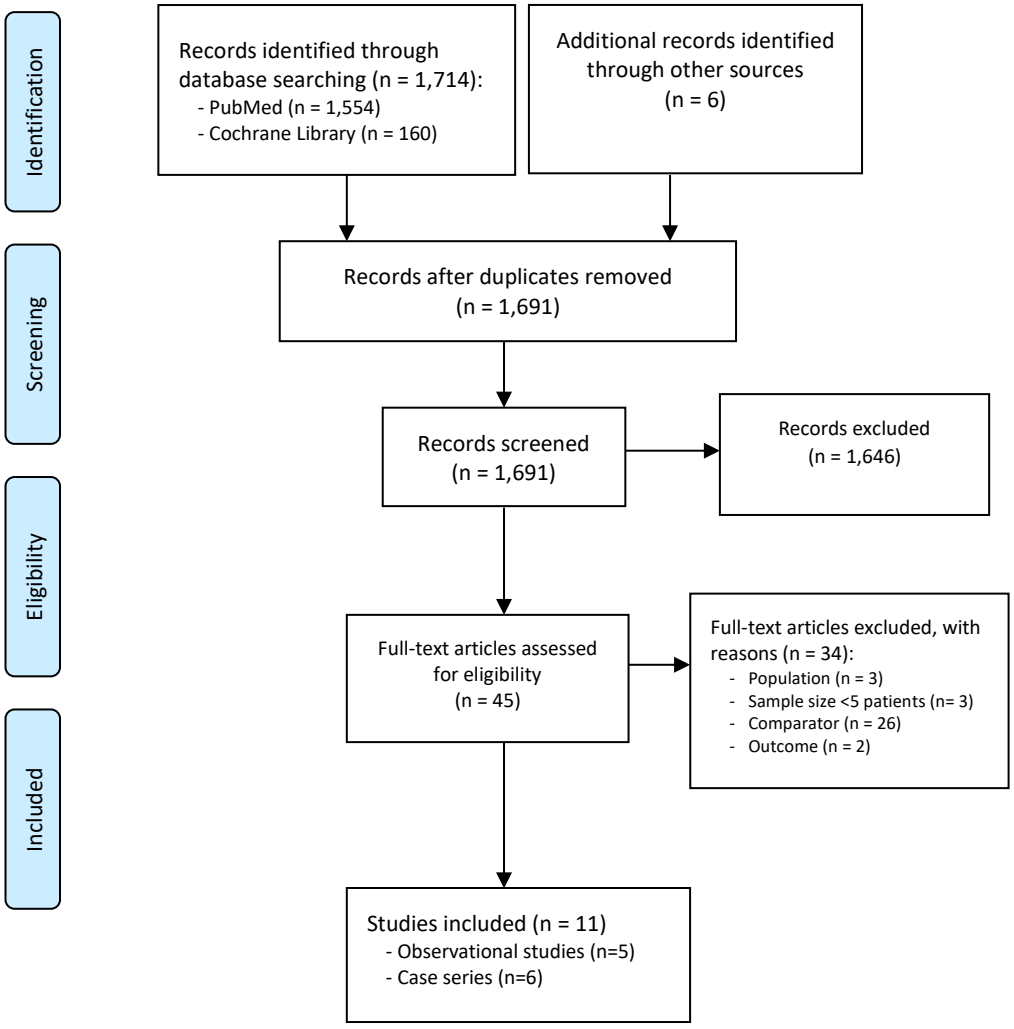
Supplementary Figure 10.—PICO 3 PRISMA flow diagram on gastropancreaticoduodenal artery pseudoaneurysms.



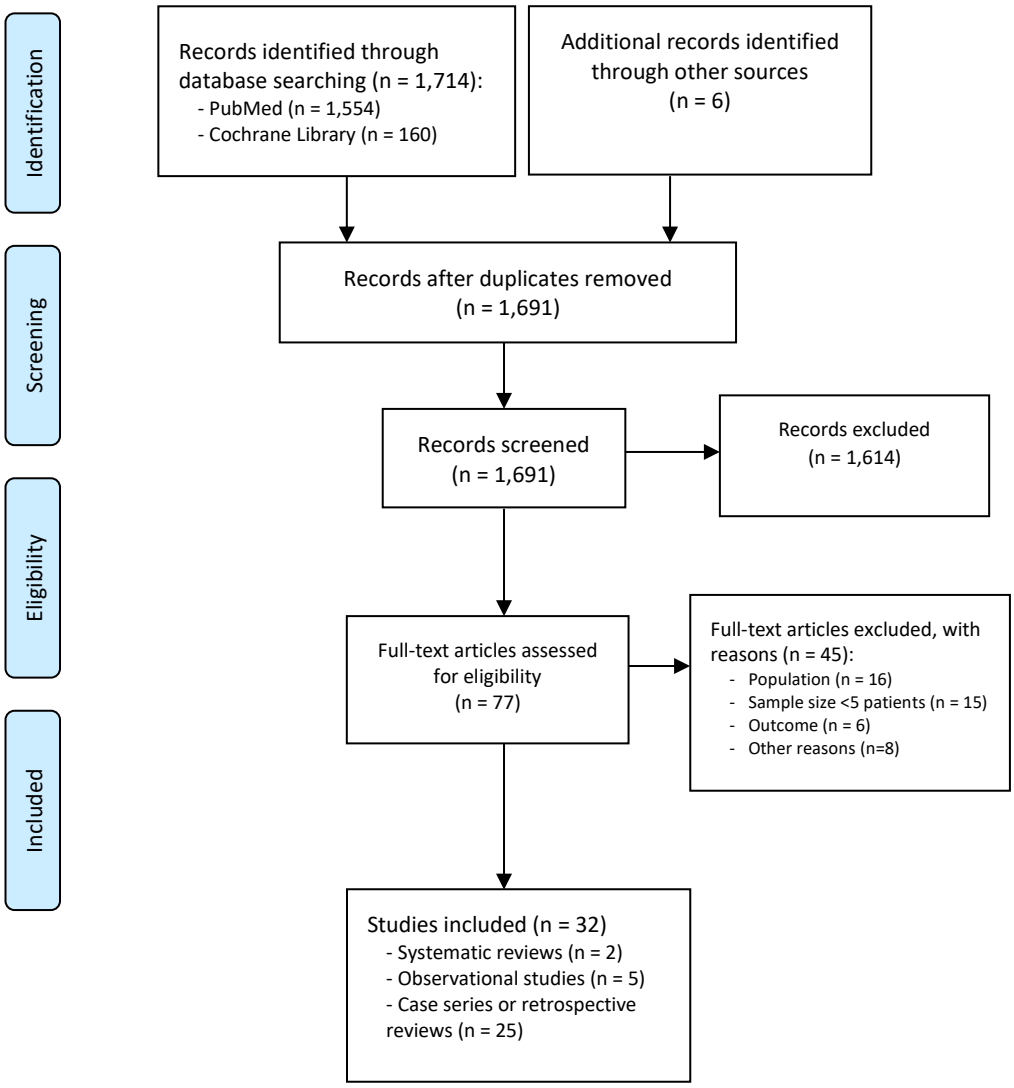
Supplementary Figure 11.—PICO 4 PRISMA flow diagram on gastropancreaticoduodenal artery pseudoaneurysms.

Supplementary Table VIII.—PICO 1, 2, 3, and 4 search strategies on hepatic artery aneurysms.

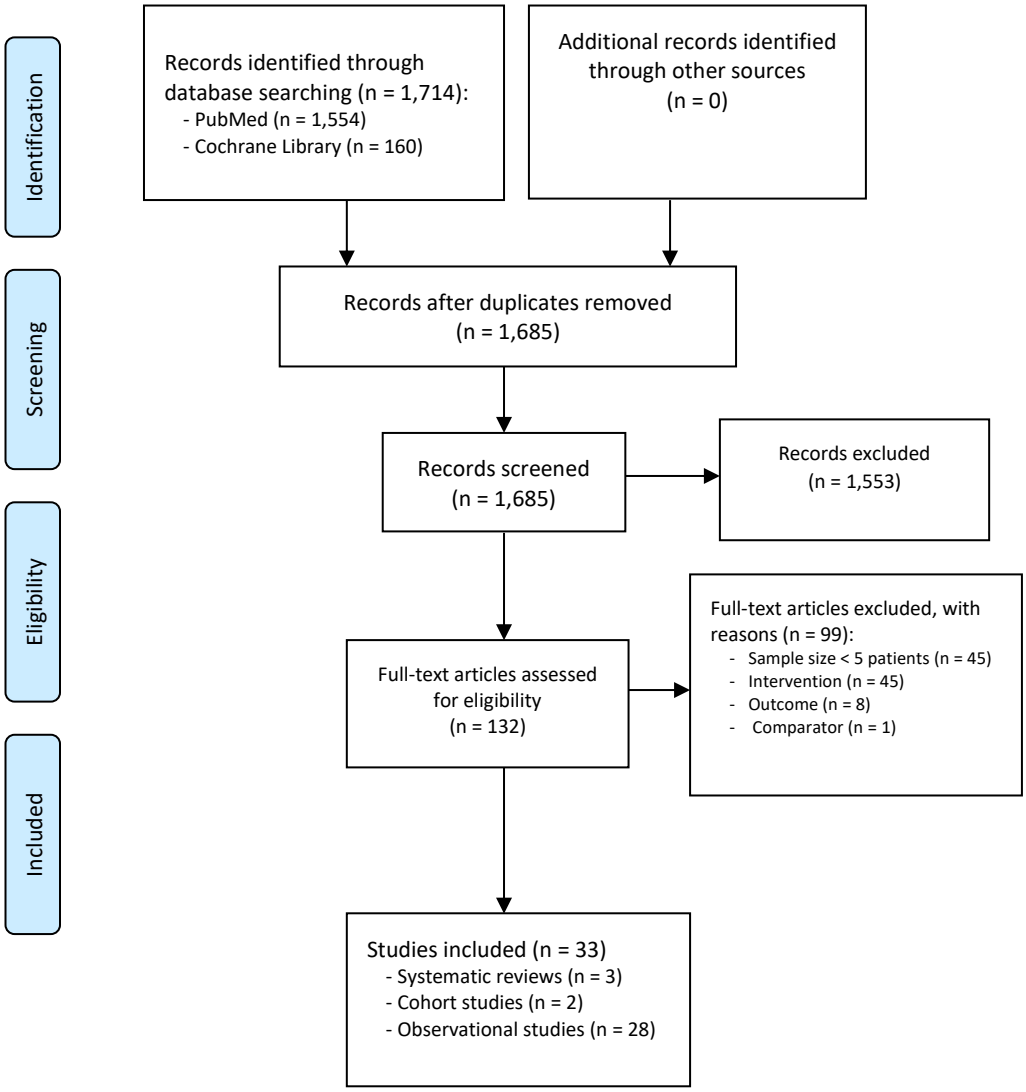
PubMed, searched on 10/05/2022		
Search	Query	Results
#1	hepatic OR liver OR "arteria hepatica"	1,309,705
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms	181,150
#3	procedure OR procedures OR surgery OR surgeries OR technique OR techniques OR operation OR operations OR intervention OR interventions OR therapy OR therapies OR management OR treatment OR treatments OR correction OR corrections OR repair OR repairs OR revascularization OR revascularizations OR reimplantation OR resection OR resections OR aneurysmectomy OR bypass OR graft OR grafts OR prosthesis OR prostheses OR endovascular OR hybrid OR hybrids	21,145,515
#4	#1 AND #2 AND #3	3,932
#5	#4 NOT ("case report"[Title] OR "case reports"[Title] OR "case reports"[Publication Type] OR "letter"[Publication Type] OR "editorial"[Publication Type] OR "comment"[Publication Type]) Filters: English, Italian	1,554
Cochrane Library, searched on 10/05/2022		
Search	Query	Results
#1	hepatic OR liver OR "arteria hepatica"	74,269
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms	5,011
#3	procedure OR procedures OR surgery OR surgeries OR technique OR techniques OR operation OR operations OR intervention OR interventions OR therapy OR therapies OR management OR treatment OR treatments OR correction OR corrections OR repair OR repairs OR revascularization OR revascularizations OR reimplantation OR resection OR resections OR aneurysmectomy OR bypass OR graft OR grafts OR prosthesis OR protheses OR endovascular OR hybrid OR hybrids	1,453,344
#4	#1 AND #2 AND #3 in Cochrane Reviews and Trials	160



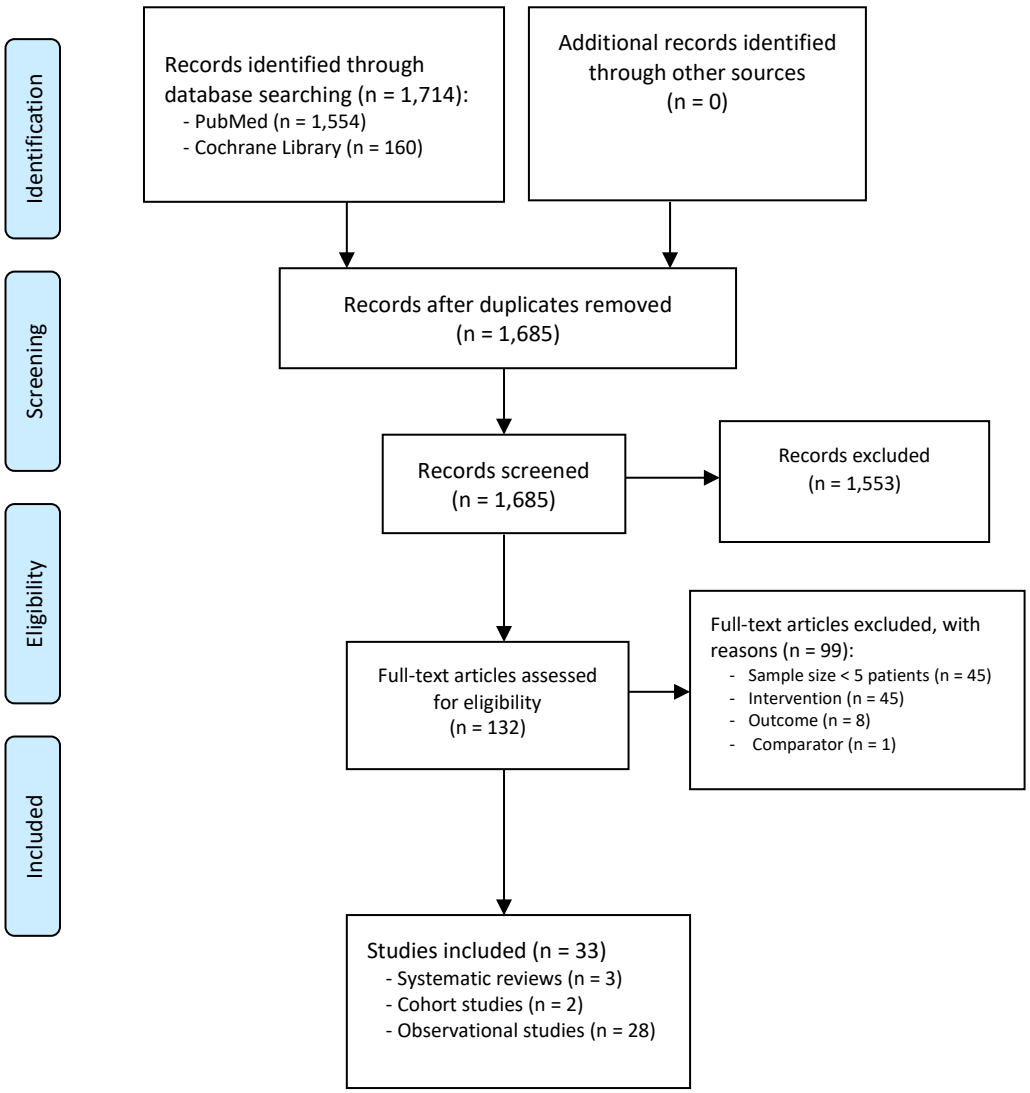
Supplementary Figure 12.—PICO 1 PRISMA flow diagram on hepatic artery aneurysms.



Supplementary Figure 13.—PICO 2 PRISMA flow diagram on hepatic artery aneurysms.



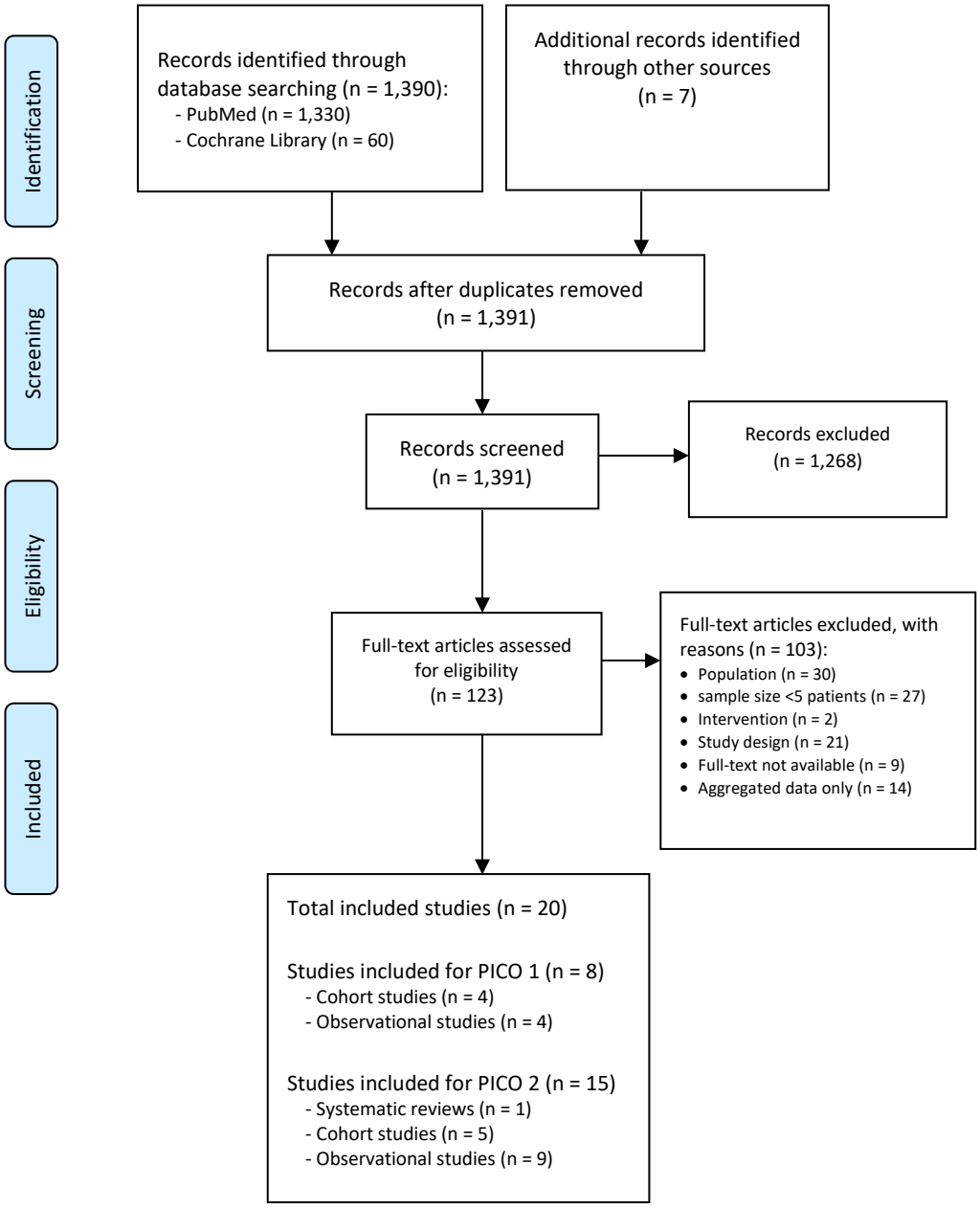
Supplementary Figure 14.—PICO 3 PRISMA flow diagram on hepatic artery aneurysms.



Supplementary Figure 15.—PICO 4 PRISMA flow diagram on hepatic artery aneurysms.

Supplementary Table IX.—PICO 1 and 2 search strategies on mesenteric artery aneurysms.

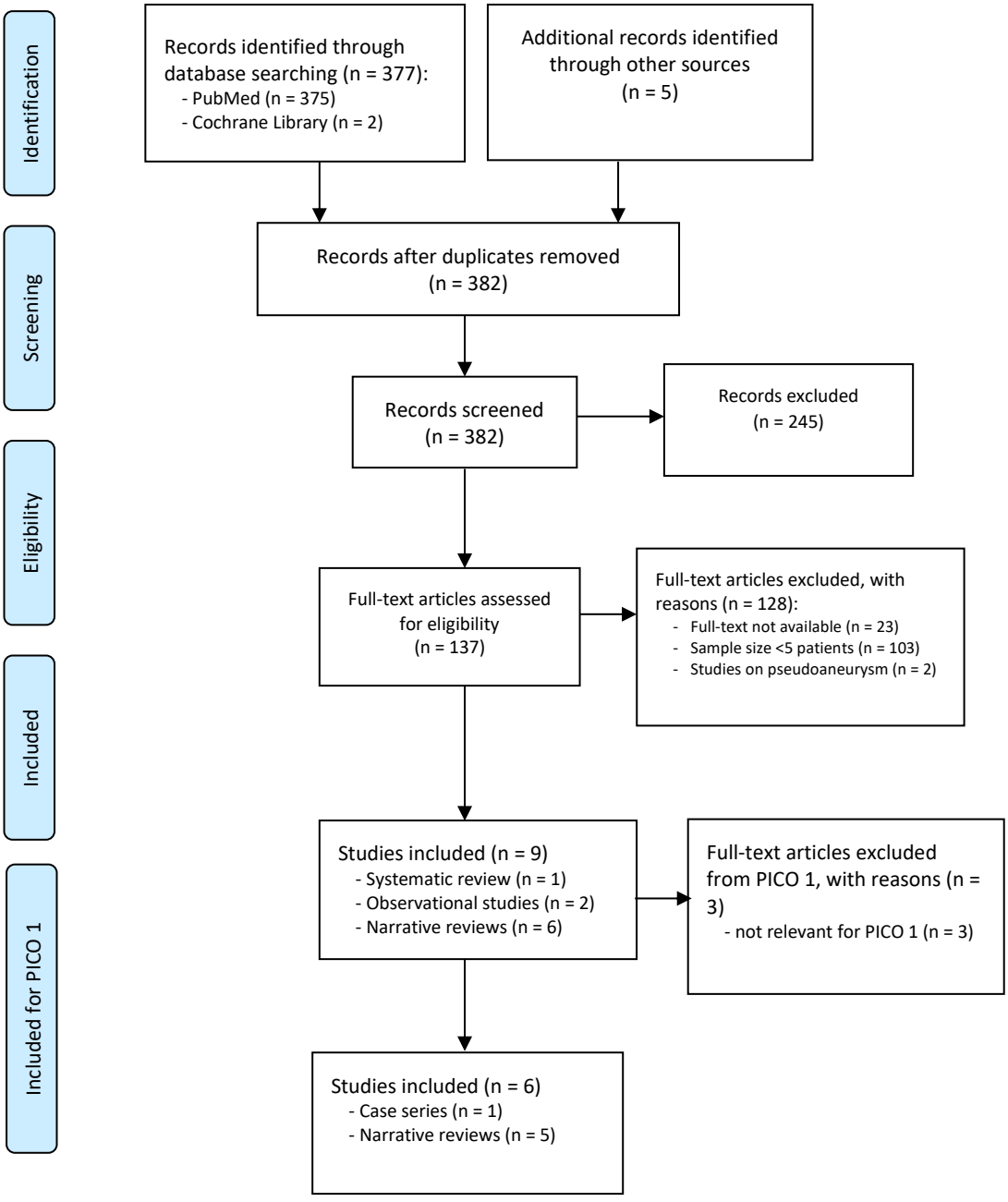
PubMed, searched on 12/05/2022		
Search	Query	Results
#1	mesenteric artery OR mesenteric arteries	29,328
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms	181,177
#3	procedure OR procedures OR surgery OR surgeries OR technique OR techniques OR operation OR operations OR intervention OR interventions OR therapy OR therapies OR management OR treatment OR treatments OR correction OR corrections OR repair OR repairs OR revascularization OR revascularizations OR reimplantation OR resection OR resections OR aneurysmectomy OR bypass OR graft OR grafts OR prosthesis OR prostheses OR endovascular OR hybrid OR hybrids	21,152,182
#4	#1 AND #2 AND #3	3,053
#5	#4 NOT ("case report"[Title] OR "case reports"[Title] OR "case reports"[Publication Type] OR "letter"[Publication Type] OR "editorial"[Publication Type] OR "comment"[Publication Type]) Filters: English, Italian	1,330
Cochrane Library, searched on 12/05/2022		
Search	Query	Results
#1	mesenteric artery OR mesenteric arteries	655
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms	5,567
#3	procedure OR procedures OR surgery OR surgeries OR technique OR techniques OR operation OR operations OR intervention OR interventions OR therapy OR therapies OR management OR treatment OR treatments OR correction OR corrections OR repair OR repairs OR revascularization OR revascularizations OR reimplantation OR resection OR resections OR aneurysmectomy OR bypass OR graft OR grafts OR prosthesis OR prostheses OR endovascular OR hybrid OR hybrids	1,469,936
#4	#1 AND #2 AND #3 in Cochrane Reviews and Trials	60



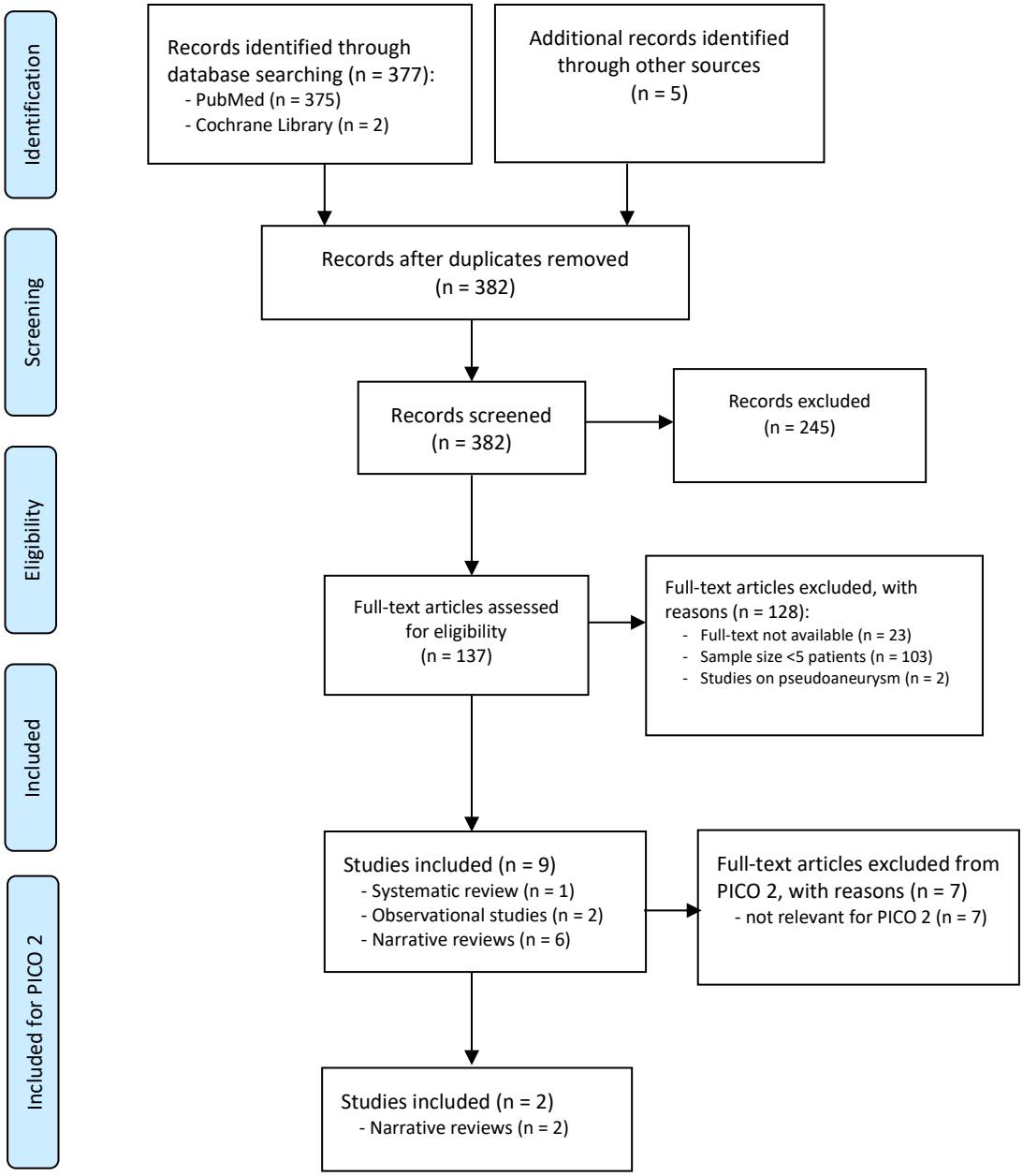
Supplementary Figure 16.—PICO 1 and 2 PRISMA flow diagram on mesenteric artery aneurysms.

Supplementary Table X.—PICO 1 and 2 search strategies on jejunal, ileal, and colic artery aneurysms.

PubMed, searched on 23/05/2022		
Search	Query	Results
#1	(jejunal arter*) OR (ileal arter*) OR (ileum arter*) OR (ileocolic arter*) OR (colic arter*)	7,023
#2	"endovascular procedures"[MeSH Terms] OR procedure* OR surg* OR technique* OR operation* OR intervention* OR therap* OR management* OR treatment OR treat* OR revascularization* OR reimplantation* OR resection* OR aneurysmectom* OR bypass* OR graft* OR prosthes* OR endovascular OR hybrid	17,823,701
#3	"aneurysm"[MeSH Terms] OR aneurysm* OR aneurism* OR "aneurysm, false"[MeSH Terms] OR pseudoaneurysm* OR pseudo-aneurysm*	181,881
#4	#1 AND #2 AND #3	452
#5	#1 AND #2 AND #3 Filters: English, Italian	375
Cochrane Library, searched on 23/05/2022		
Search	Query	Results
#1	((jejunal arter*) OR ((ileal arter*) OR (ileum arter*)) OR (ileocolic arter*) OR (colic arter*)):ti,ab,kw (Word variations have been searched)	143
#2	(procedure* OR surg* OR technique* OR operation* OR intervention* OR therap* OR management* OR treatment OR treat* OR revascularization* OR reimplantation* OR resection* OR aneurysmectom* OR bypass* OR graft* OR prosthes* OR endovascular OR hybrid):ti,ab,kw (Word variations have been searched)	1,472,493
#3	((aneurysm*) OR (aneurism*) OR (pseudoaneurysm*) OR (pseudo-aneurysm*)):ti,ab,kw (Word variations have been searched)	5,147
#4	#1 AND #2 AND #3 in Cochrane Reviews and Trials	2



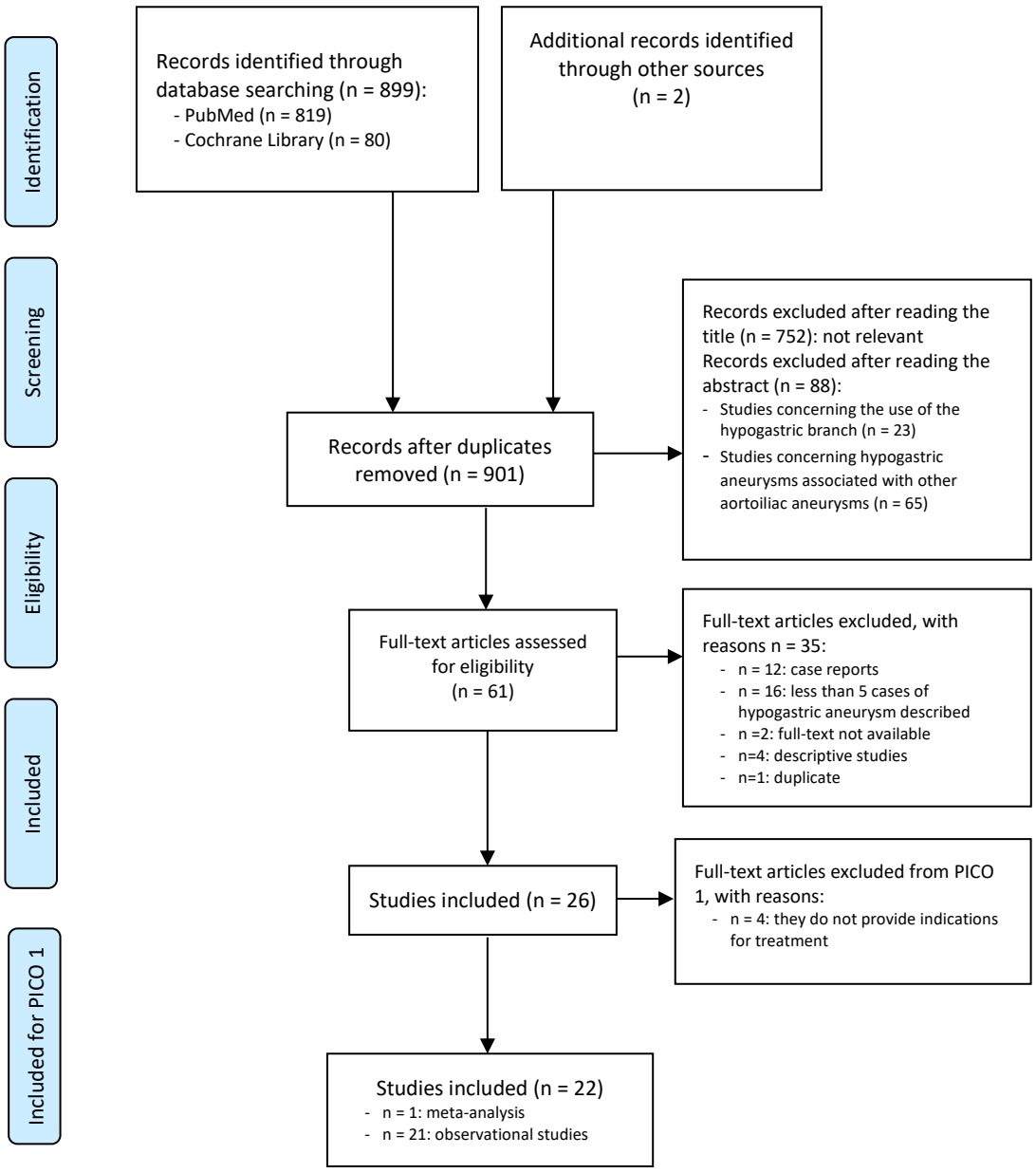
Supplementary Figure 17.—PICO 1 PRISMA flow diagram on jejunal, ileal, and colic artery artery aneurysms.



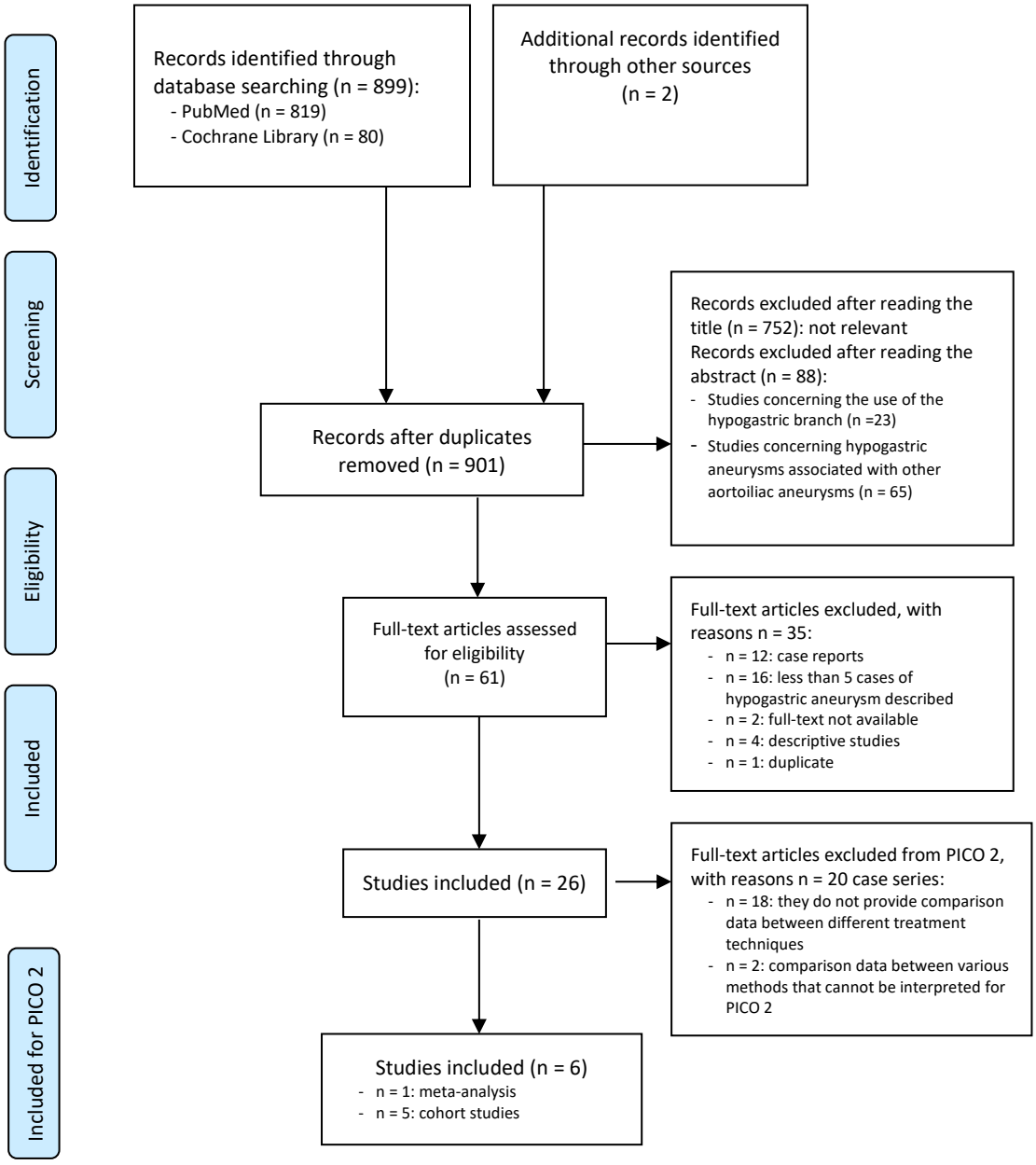
Supplementary Figure 18.—PICO 2 PRISMA flow diagram on jejunal, ileal, and colic artery artery aneurysms.

Supplementary Table XI.—PICO 1 and 2 search strategies on isolated hypogastric artery aneurysms.

PubMed, searched on 12/05/2022		
Search	Query	Results
#1	hypogastric OR internal iliac	10,977
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms	181,180
#3	procedure OR procedures OR surgery OR surgeries OR technique OR techniques OR operation OR operations OR intervention OR interventions OR therapy OR therapies OR management OR treatment OR treatments OR correction OR corrections OR repair OR repairs OR revascularization OR revascularizations OR reimplantation OR resection OR resections OR aneurysmectomy OR bypass OR graft OR grafts OR prosthesis OR prostheses OR endovascular OR hybrid OR hybrids	21,152,306
#4	#1 AND #2 AND #3	1,704
#5	#4 NOT ("case report"[Title] OR "case reports"[Title] OR "case reports"[Publication Type] OR "letter"[Publication Type] OR "editorial"[Publication Type] OR "comment"[Publication Type]) Filters: English, Italian	819
Cochrane Library, searched on 12/05/2022		
Search	Query	Results
#1	hypogastric OR internal iliac	994
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms	5,567
#3	procedure OR procedures OR surgery OR surgeries OR technique OR techniques OR operation OR operations OR intervention OR interventions OR therapy OR therapies OR management OR treatment OR treatments OR correction OR corrections OR repair OR repairs OR revascularization OR revascularizations OR reimplantation OR resection OR resections OR aneurysmectomy OR bypass OR graft OR grafts OR prosthesis OR prostheses OR endovascular OR hybrid OR hybrids	1,469,935
#4	#1 AND #2 AND #3 in Cochrane Reviews and Trials	80



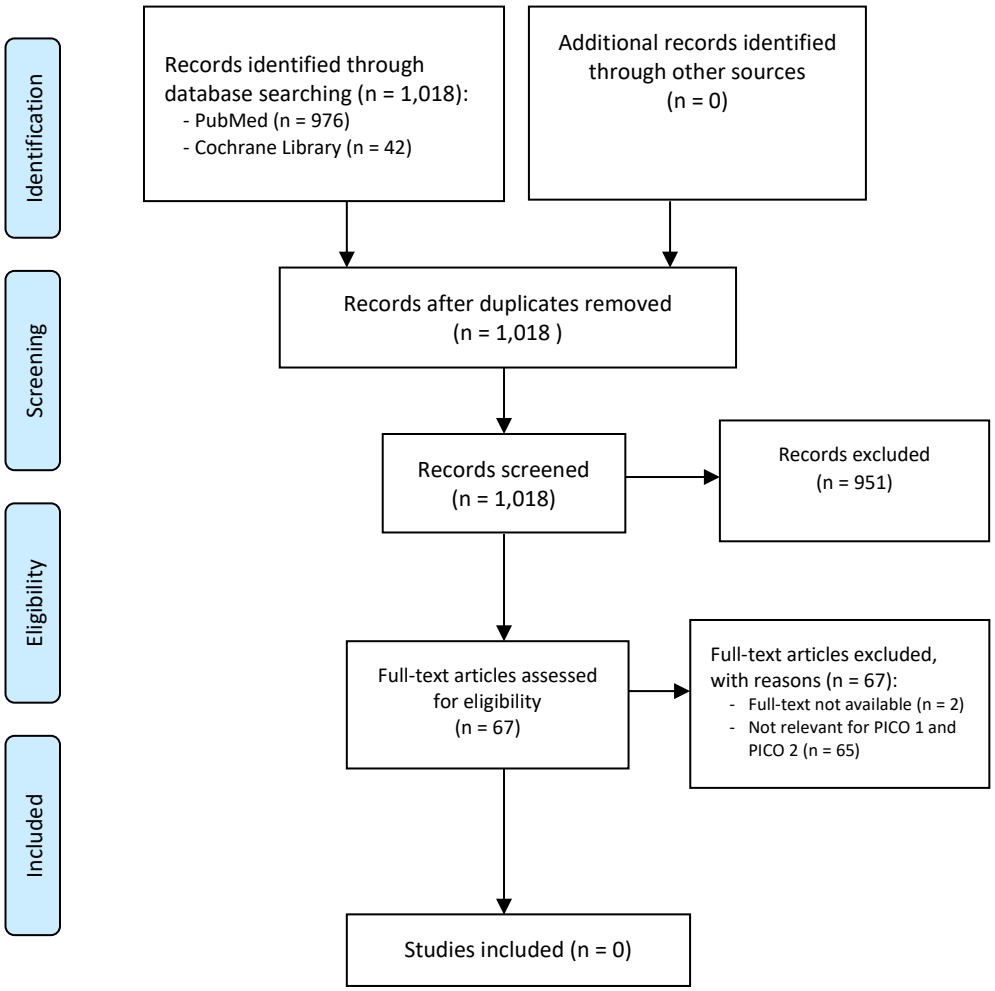
Supplementary Figure 19.—PICO 1 PRISMA flow diagram on isolated hypogastric artery artery aneurysms.



Supplementary Figure 20.—PICO 2 PRISMA flow diagram on isolated hypogastric artery artery aneurysms.

Supplementary Table XII.—PICO 1 and 2 search strategies on medical therapy and follow-up.

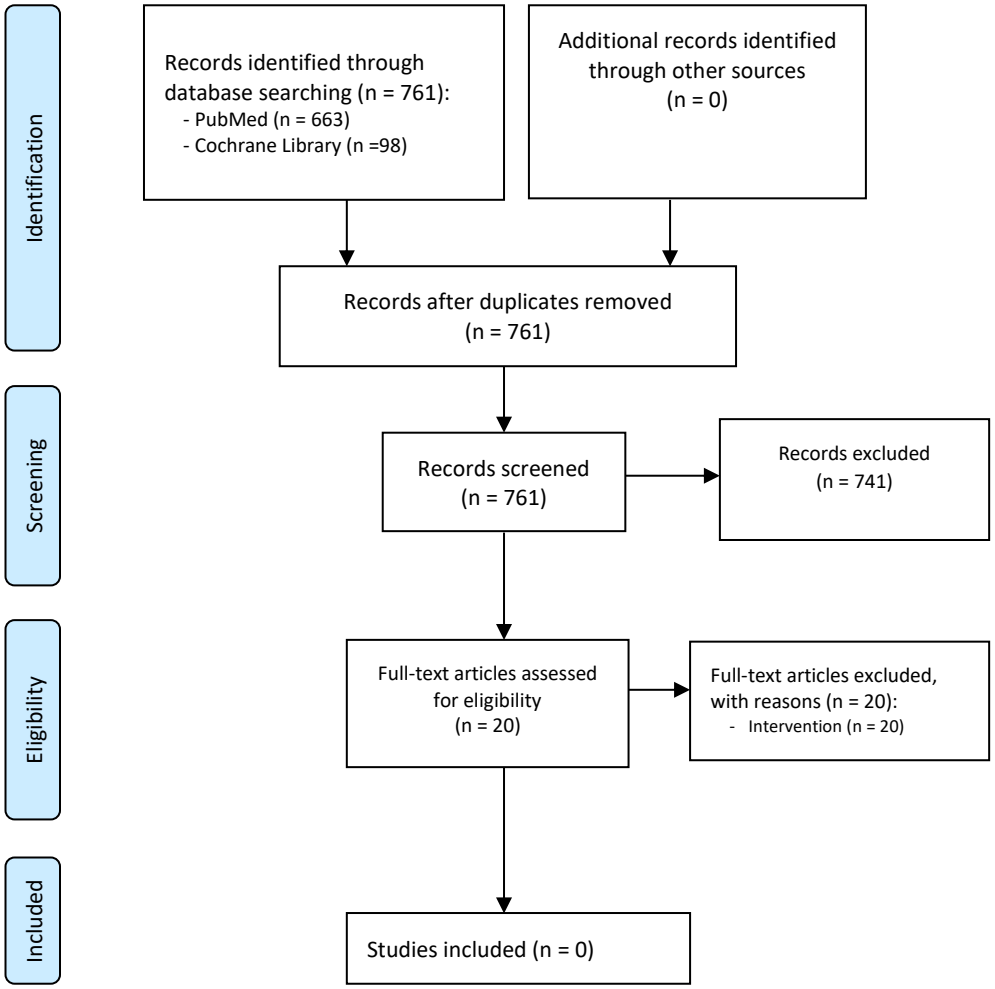
PubMed, searched on 31/05/2022		
Search	Query	Results
#1	((visceral OR renal OR splenic OR lienal OR hepatic OR celiac OR coeliac OR gastric OR gastroepiploic OR mesenteric OR jejunal OR ileal OR iliac OR ilial OR colic OR pancreaticoduodenal OR gastroduodenal OR pancreatico-duodenal OR gastro-duodenal OR hypogastric OR "internal iliac") AND (artery OR arteries)) OR "arteria coeliaca" OR "arteria gastrica" OR "arteria gastroduodenalis" OR "arteria gastroepiploica" OR "arteria hepatica" OR "arteria lienalis" OR "arteria mesenterica" OR "arteria renalis" OR "celiac axis" OR "celiac trunk" OR "coeliac axis" OR "coeliac trunk" OR "truncus celiacus" OR "truncus coeliacus"	196,344
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms	181,512
#3	"Computed Tomography Angiography"[Mesh] OR computed tomography angiography OR "Magnetic Resonance Angiography"[Mesh] OR magnetic resonance angiography OR "Ultrasonography, Doppler, Duplex"[Mesh] OR ultrasonography doppler duplex	130,315
#4	follow-up OR "follow up" OR surveillance OR monitoring	5,057,756
#5	#1 AND #2 AND #3 AND #4	1,604
#6	#5 NOT ("case report"[Title] OR "case reports"[Title] OR "case reports"[Publication Type] OR "letter"[Publication Type] OR "editorial"[Publication Type] OR "comment"[Publication Type]) Filters: English, Italian	976
Cochrane Library, searched on 31/05/2022		
Search	Query	Results
#1	((visceral OR renal OR splenic OR lienal OR hepatic OR celiac OR coeliac OR gastric OR gastroepiploic OR mesenteric OR jejunal OR ileal OR iliac OR ilial OR colic OR pancreaticoduodenal OR gastroduodenal OR pancreatico-duodenal OR gastro-duodenal OR hypogastric OR "internal iliac") AND (artery OR arteries)) OR "arteria coeliaca" OR "arteria gastrica" OR "arteria gastroduodenalis" OR "arteria gastroepiploica" OR "arteria hepatica" OR "arteria lienalis" OR "arteria mesenterica" OR "arteria renalis" OR "celiac axis" OR "celiac trunk" OR "coeliac axis" OR "coeliac trunk" OR "truncus celiacus" OR "truncus coeliacus"	12,849
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms	5,592
#3	computed tomography angiography OR magnetic resonance angiography OR ultrasonography doppler duplex	4,265
#4	follow-up OR "follow up" OR surveillance OR monitoring	383,418
#5	#1 AND #2 AND #3 AND #4	42



Supplementary Figure 21.—PICO 1 and 2 PRISMA flow diagram on medical therapy and follow-up.

Supplementary Table XIII.—PICO 3 and 4 search strategies on medical therapy and follow-up.

PubMed, searched on 27/07/2022		
Search	Query	Results
#1	((visceral OR renal OR splenic OR lienal OR hepatic OR celiac OR coeliac OR gastric OR gastroepiploic OR mesenteric OR jejunal OR ileal OR iliac OR ilial OR colic OR pancreaticoduodenal OR gastroduodenal OR pancreatico-duodenal OR gastro-duodenal OR hypogastric OR "internal iliac") AND (artery OR arteries)) OR "arteria coeliaca" OR "arteria gastrica" OR "arteria gastroduodenalis" OR "arteria gastroepiploica" OR "arteria hepatica" OR "arteria lienalis" OR "arteria mesenterica" OR "arteria renalis" OR "celiac axis" OR "celiac trunk" OR "coeliac axis" OR "coeliac trunk" OR "truncus celiacus" OR "truncus coeliacus"	197,271
#2	aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms	182,851
#3	antithrombotic OR anticoagulant OR antiplatelet OR heparin OR DOAC OR aspirin OR clopidogrel OR ticagrelor OR rivaroxaban OR apixaban OR dabigatran OR edoxaban OR statin OR betablockers OR "medical therapy" OR "drug therapy" OR "pharmacological therapy" OR "pharmacologic therapy" OR "medical treatment" OR "drug treatment" OR "pharmacological treatment" OR "pharmacologic treatment" OR "smoking cessation" OR antihypertensive OR angiotensin-converting enzyme inhibitors OR ACE-I OR angiotensin II receptor 1 antagonists OR ATIIR1 OR antidiabetic	3,482,874
#4	#1 AND #2 AND #3	1,531
#5	#4 NOT ("case report"[Title] OR "case reports"[Title] OR "case reports"[Publication Type] OR "letter"[Publication Type] OR "editorial"[Publication Type] OR "comment"[Publication Type]) Filters: English, Italian	663
Cochrane Library, searched on 27/07/2022		
Search	Query	Results
#1	(((visceral OR renal OR splenic OR lienal OR hepatic OR celiac OR coeliac OR gastric OR gastroepiploic OR mesenteric OR jejunal OR ileal OR iliac OR ilial OR colic OR pancreaticoduodenal OR gastroduodenal OR pancreatico-duodenal OR gastro-duodenal OR hypogastric OR "internal iliac") AND (artery OR arteries)) OR "arteria coeliaca" OR "arteria gastrica" OR "arteria gastroduodenalis" OR "arteria gastroepiploica" OR "arteria hepatica" OR "arteria lienalis" OR "arteria mesenterica" OR "arteria renalis" OR "celiac axis" OR "celiac trunk" OR "coeliac axis" OR "coeliac trunk" OR "truncus celiacus" OR "truncus coeliacus"):ti,ab,kw (Word variations have been searched)	11,450
#2	(aneurysm OR aneurysms OR microaneurysm OR microaneurysms OR pseudoaneurysm OR pseudoaneurysms):ti,ab,kw (Word variations have been searched)	5,311
#3	(antithrombotic OR anticoagulant OR antiplatelet OR heparin OR DOAC OR aspirin OR clopidogrel OR ticagrelor OR rivaroxaban OR apixaban OR dabigatran OR edoxaban OR statin OR betablockers OR "medical therapy" OR "drug therapy" OR "pharmacological therapy" OR "pharmacologic therapy" OR "medical treatment" OR "drug treatment" OR "pharmacological treatment" OR "pharmacologic treatment" OR "smoking cessation" OR antihypertensive OR angiotensin-converting enzyme inhibitors OR ACE-I OR angiotensin II receptor 1 antagonists OR ATIIR1 OR antidiabetic):ti,ab,kw (Word variations have been searched)	496,535
#4	#1 AND #2 AND #3 in Cochrane Reviews and Trials	98



Supplementary Figure 22.—PICO 3 and 4 PRISMA flow diagram on medical therapy and follow-up.

Interpretation of selected evidence

1. DIAGNOSIS AND SCREENING

PICO 1.1 Clinical question: In patients with suspected aneurysm/pseudoaneurysm of visceral or renal artery, is Computed Tomography (CT) angiography more accurate than other modalities for the diagnosis and indication for treatment?

The literature search identified one non-analytical article [8] and five review articles [9-13] relevant to the proposed PICO. Although the included studies partially analyzed the same population of interest (patients with suspected aneurysm of the visceral or renal artery), they addressed considerably different aspects and did not draw a common conclusion regarding the accuracy of CT angiography. The five reviews, despite the lack of a dedicated design, suggested that CT angiography should be the first-choice imaging in both urgent and elective cases, due to its higher accuracy, lower invasiveness, and better ease of execution, compared with other imaging modalities.

PICO 1.2 Clinical question: Should patients diagnosed with visceral or renal artery aneurysms be screened with additional imaging to look for potential concomitant aneurysms in different locations to prevent complications, instead of forgoing further diagnostic examinations?

To date, no studies have found an answer to the proposed clinical question. There are no guidelines or studies supporting the need for additional investigations to detect concomitant aneurysms in other locations. CT angiography alone, widely employed nationwide, allows to diagnose and plan the treatment of the detected aneurysm. With the same exam, the presence of concomitant aneurysms in other locations within the same imaging scans can be evaluated. Given the widespread availability of this imaging modality, and the limited risks for the patients, the panel of experts decided to formulate a good clinical practice point recommendation in this regard.

PICO 1.3 Clinical question: Should patients with visceral or renal artery aneurysms be screened for associated underlying pathologies?

To date, literature has provided limited evidence in support of the screening for associated underlying pathologies. Despite analyzing the same population of interest (patients with visceral or renal artery aneurysms), the included studies addressed considerably different aspects, and did not draw a common conclusion regarding the possible screening for associated underlying conditions. One study, despite the low number of patients and the lack of a dedicated design, suggested that in individuals with visceral or renal artery aneurysms an ultrasound screening for popliteal aneurysms might be indicated [14]. The second selected article endorsed the assessment of fibromuscular dysplasia in patients with visceral or renal artery aneurysms [15].

2. INDICATIONS AND TREATMENT OPTIONS

2.1 RENAL ARTERY ANEURYSMS

PICO 2.1.1 Clinical question: In a patient with an aneurysm/pseudoaneurysm of the renal arteries, when is it justified to propose a surgical/endovascular treatment compared to medical therapy/follow-up alone to improve the outcome?

There are no recent randomized controlled trials in the literature regarding the management of visceral aneurysms and renal arteries. The most significant meta-analysis and systematic review on the topic was published by Barrionuevo et al. in 2019 and analyzes all the works published between 1980 and 27 March 2017 concerning visceral and renal arteries aneurysms; this meta-analysis takes into consideration 1279 renal artery aneurysms, of which 358 treated with an endovascular approach and 921 treated with an open surgical approach [16]. The growth rate of renal artery aneurysms is very low (about 0.06 to 0.6 mm per year) and the natural history of aneurysms larger than 2 cm is associated with a low risk of rupture and a slow growth rate [17-19]. The most recent literature, indeed, has highlighted a threshold greater than or equal to 3 cm in diameter to give the indication for the elective treatment; however, in consideration of the characteristics of individual cases, treatment threshold may variate below 3 cm in diameter in the following cases: distal location, saccular morphology and rapid growth. From the analysis of selected studies, it emerged that the rupture of renal aneurysms is associated with a mortality equal to 10% in the general population, therefore emergency repair surgery is indicated in this case [20, 21]. Renal artery pseudoaneurysms, as well as all other visceral arteries pseudoaneurysms, have a higher risk of rupture than true aneurysms [16], and for this reason literature generally recommends the treatment of a renal artery pseudoaneurysm regardless of its diameter. Pregnancy is associated with an increased risk of aneurysm rupture, and the maternal and fetal mortality rates associated with aneurysmal rupture reported in literature range from 56% to 84% and 82% to 100%, respectively. Evidence supports intervention in patients of childbearing age with renal artery aneurysm and acceptable operative risk even in case of diameters less than 3 cm [22, 23].

PICO 2.1.2 Clinical question: Which intervention/procedure is preferable in terms of outcome in patients with renal artery aneurysm/pseudoaneurysm?

We identified a single systematic review and meta-analysis and two comparative cohort studies comparing endovascular treatment with open surgery [16, 24, 25]. Barrionuevo et al. and Gwon et al. showed substantial clinical similarity between endovascular and open surgery approaches, with only a reduced but not statistically significant rate of reinterventions in the open technique compared to the endovascular technique (0.16 [95% CI, 0.00-0.42] vs 0.03 [95% CI, 0.00-0.08]) [16, 24]. Reintervention rate was substantially overlapping in the results reported by Li et al., as well as the rate of complications, and antihypertensive efficacy [25]. In terms of blood loss, duration of the procedure, intensive care unit stay, and hospitalization Li et al. reported the superiority of endovascular technique, although a lower reintervention rate seemed to characterize the open technique, which justifies a preferential surgical approach, especially considering that these patients are often young with a prolonged life expectancy [25]. Furthermore, literature showed satisfactory results regarding open surgery in the treatment of complex aneurysms [26]. On the other hand, the endovascular approach, when technically feasible, is preferred in patients with multiple comorbidities and a poor life expectancy [17, 27, 28].

As demonstrated in literature, ex-vivo surgical technique is safe and effective in treating the majority of complex aneurysms [29]. Although outcomes were not significantly different when compared with open and endovascular surgery, autotransplant is more effective in preserving renal function [24]. Therefore, this technique should be preferred in complex aneurysms based on location or morphology, where prolonged ischemia time (>35 minutes) would expose to a higher risk of renal damage, and in patients with reduced renal function or those with a single functioning kidney [24].

Literature review has shown encouraging results on the use of flow-modulating stents, micromesh stents, and in vivo overlapping stent technique. These therapeutic strategies have demonstrated vessel patency rates slightly below 94%, almost 90% complete sac thrombosis, and a 93.4% reduction/stabilization of the sac [30]. According to this systematic review and meta-analysis, the outcomes were generally reported for aneurysms of the abdominal visceral arteries (including 29 renal artery aneurysms out of a total of 225 visceral arteries aneurysms). Therefore, in selected situations based on anatomical characteristics, such as aneurysms or pseudoaneurysms involving the main branch or collateral branches that need to be preserved, the use of covered or uncovered stents should be taken into consideration [30].

2.2 SPLENIC ARTERY ANEURYSMS

PICO 2.2.1 Clinical Question: When is it justified to propose surgical/endovascular treatment, compared with medical therapy/follow-up alone, to improve the outcomes of patients with a splenic artery aneurysm/pseudoaneurysm?

In almost all selected papers in case of ruptured aneurysms/pseudoaneurysms, authors have agreed that emergency surgical/endovascular treatment is recommended. In case of symptomatic aneurysms/pseudoaneurysms and in case of pseudoaneurysms, authors agree that surgical/endovascular treatment is recommended as soon as possible [31-34]. A systematic review and meta-analysis comparing management and outcome of open surgery versus endovascular treatment versus conservative treatment, conducted by Hogendoorn et al. [35], based on data collected from 1321 patients in 47 articles, together with articles by other authors [36, 37], suggest active surveillance with both clinical and imaging-based follow-up in case of: a) splenic artery aneurysms less than 3 cm in diameter, b) dimensional stability at follow-up imaging, c) significant comorbidities, d) limited life expectancy. In a systematic review of 74 patients with splenic artery aneurysms, Batagini et al. [38] have highlighted that most splenic artery aneurysms remain stable and they have identified portal hypertension as the main risk factor for volume progression. In almost all selected papers, authors have indicated elective treatment in case of splenic artery aneurysms more than 3 cm in diameter [16, 35, 36, 39]. Chaer et al. [39], authors of the most recent American vascular surgery guidelines on the management of visceral aneurysms, propose observation based on a more controversial indication for the treatment of splenic artery aneurysms in asymptomatic patients ranging from 2 to 3 cm in diameter. On the other hand, Pulli et al. [40], Venturini et al. [41-43], Abbas et al. [32], Wang et al. [44], and Dorigo et al. [45] have suggested elective treatment. In the case of splenic artery aneurysms less than 2 cm in diameter, in the absence of other risk factors, elective treatment is suggested only in cases of demonstrated rapid volumetric growth [16, 39, 46, 47]. The possible protective role of vessel wall calcifications is also being debated. According to Lakin et al. [47] and Sano et al. [48], wall calcifications do have a protective role and may slow down aneurysm growth. However, such protective factor is questionable for other authors [49]. Because of the high risk of rupture, portal hypertension and liver transplant are significant objective elements in favour of treating splenic artery aneurysms, regardless of their size, as argued by Phan et al. [50] and Kobori et al [51]. Another major risk factor for ruptured splenic artery aneurysms is pregnancy, as highlighted by Ha et al. [52] and Aung et al. [53]. Specifically, in a review on 32 ruptured aneurysms in pregnant women, Ha et al. report how the average diameter of half of the splenic artery aneurysms was less than 2 cm; however, according to other authors, such as Nanez et al. [54], the risk of ruptured splenic artery aneurysms in pregnancy is relatively rare. The timing of possible treatment in pregnancy of splenic artery aneurysms is still a matter of debate. Surgical treatment is generally suggested during the second trimester, when embryogenesis is completed, though the size of the uterus has not yet precluded exposure of the aneurysm [52]. In the case of detection of splenic artery aneurysms in a young woman of childbearing age, close imaging monitoring (Computed Tomography, Magnetic Resonance Imaging, Doppler ultrasound) and treatment in case of rapid volumetric growth are suggested [16, 39, 55-57].

PICO 2.2.2 Clinical Question: In a patient with a splenic artery aneurysm/pseudoaneurysm, which intervention/procedure should be carried out in order to obtain better outcomes?

In case of emergency/urgency (ruptured, symptomatic splenic artery aneurysms, pseudoaneurysms), the choice between surgical and endovascular treatment depends on many factors, including the feasibility of the two treatment options, which is also influenced by a) logistics, b) the type of splenic artery aneurysm (true or pseudoaneurysm), c) its location, d) its morphological features, e) patient's age, and f) patient's comorbidities. In general, the endovascular option is considered to be safer in terms of lower morbidity, mortality, and hospitalization time rates. Mortality rates and treatment costs are lower in both ruptured and intact splenic artery aneurysm treatments. In a systematic review and meta-analysis carried out by Hogendoorn et al. [35], the mortality rate 30 days after surgical treatment versus endovascular treatment was found to be 5% versus 0.6% respectively, in case of intact splenic artery aneurysms (9% vs 2%, in case of ruptured cases). Also, the average hospitalization time after surgery was found to be significantly higher than after endovascular treatment (9.8 vs 2.0 days). Considering splenic artery aneurysms elective treatment, Hogendoorn et al. [58] pointed out, in another systematic review, that compared with open surgery, overall costs are lower in case of endovascular treatment (-$3,384), which, however, has higher reintervention rates. Therefore, whenever possible, also based on clinical, anatomical, multidisciplinary, and logistic evaluations, endovascular treatment is recommended over surgical treatment because it is less invasive, it has lower morbidity and mortality rates, lower costs and shorter hospitalization times, both in elective treatment and in emergency settings [31, 42, 43, 59-66], even though surgical treatment has lower reintervention rates. In case of splenic artery aneurysms during pregnancy, the choice is more debated, partly because of issues related to the impact of radiation on the foetus [52, 53, 67]. In case of hilar splenic artery aneurysms, the choice of treatment is also debated. Hilar aneurysms may be treated endovascularly only by means of embolization with sacrifice of the target vessel if the aneurysms are fusiform, with a consequent higher risk of splenic infarction [41, 68, 69]. Again, based on clinical, anatomical, multidisciplinary, and logistical evaluations, although surgical treatment has been advocated for the treatment of giant

splenic artery aneurysms more than 5 cm in diameter, especially in case of compressive effect [70], the endovascular option may also be considered [71].

2.3 CELIAC ARTERY ANEURYSMS

PICO 2.3.1 Clinical question: In patients with celiac artery aneurysm/pseudoaneurysm, when is surgical and/or endovascular intervention indicated against medical therapy alone to reduce the risk of rupture?

In patients with celiac artery aneurysms, data collected indicate that intervention is recommended in asymptomatic patients when aneurysm size is 2 cm or greater [16, 38, 72-94]. Symptomatic celiac tripod aneurysms should be treated regardless of their size. Pseudoaneurysms of the celiac artery should always be carefully evaluated and, also in this case, treated regardless of their size [16, 38, 72-92]. In a single paper in which medical therapy was indicated (wait-and-see), aneurysms growth was almost zero at one-year follow-up [38]. In asymptomatic patients with known celiac artery aneurysms smaller than 2 cm in size, follow-up may be indicated and treatment should be performed when aneurysm size is greater than or equal to 2 cm. Literature suggests the treatment of celiac artery aneurysms in special cases as well (women of childbearing age, patients in whom liver transplantation is planned, etiology), even if without reporting a dedicated case history [73, 75, 80]. Regardless of the proposed intervention, data suggest a clinical benefit to patients in terms of quality of life, yet risks associated with surgery must be weighed against the possible benefit of conservative treatment considering the high risk of rupture and patient comorbidities [88, 89]. The overall number of patients evaluated allows a rather reliable assessment regarding this PICO and the data obtained from the authors' analysis was considered quite relevant to the target population. The risk of bias is considered unclear.

PICO 2.3.2 Clinical question: In patients with celiac artery aneurysm/pseudoaneurysm, with an indication for intervention, is endovascular treatment more suitable than open surgery to improve clinical success?

Many of the narrative reviews evaluated both procedures [73, 79-84, 86, 93, 94], with only a couple of observational studies reporting a direct comparison between endovascular and open treatment [85, 95]; most observational studies reported results regarding a single treatment option [72, 74, 75-77, 79, 96-103], whilst others were simple narrative reviews [78, 87, 104, 105]. A single systematic review compared the mortality and complications of the two techniques, commenting on the absence of direct comparisons [16]. Despite the heterogeneity of all these studies, the data obtained from the authors' evaluation were considered quite relevant to the target population. The risk of bias was considered unclear/low. The analysis performed on the population with celiac artery aneurysms showed that endovascular intervention may represent the first choice, especially in cases of favorable anatomy or severe comorbidities [16, 72, 75, 82, 87, 94, 96, 102]. The open surgical option might be considered the best option in patients with hostile anatomy, in case of failure of endovascular treatment or in emergency situations and in cases with severe hemodynamic instability [16, 73, 77, 79, 81, 83-85, 93, 95, 99]. Although there was a substantial overlap in efficacy in the medium term between the two interventions, the endovascular treatment offers the benefit of shorter hospital stay and a reduced number of postoperative complications over open surgery. The most severe complications, although statistically not significant, include possible organ ischemia secondary to stent or bypass occlusion or potential bleeding following artery rupture, regardless of the type of approach used [16, 75, 76, 79, 82, 88-90, 97]. Considering the greater invasiveness of the procedure itself, open surgical intervention has a potentially more severe impact on patients' lives, particularly on districts such as the intestinal tract (e.g., transit delay) and cardiac district (e.g., myocardial ischemia, heart failure) [77, 85, 100]. Regardless of the type of intervention, celiac artery revascularization using stents or bypass should be preferred versus ligature or embolization to preserve function [81, 84, 93]. Although complication rates differed considerably between the two interventions, treatment of celiac artery aneurysms is acceptable to both the patient and family members.

2.4 GASTROPANCREATICODUODENAL ARTERIES ANEURYSMS

PICO 2.4.1 Clinical question: In patients with aneurysms of the gastropancreaticoduodenal arteries, when is it justified to propose a surgical/endovascular treatment rather than medical therapy/follow up alone to improve the outcomes?

There are no randomised controlled trials responding to the PICO question. Among the most recent articles, two reviews [106, 107] and two case series [108, 109] are available. The analysed studies present overlapping results and conclusions. Specifically, it was found that the risk of rupture of aneurysms of the gastropancreaticoduodenal arteries was independent from their size and that the technical success of both endovascular and open elective treatment was satisfactory (90% according to Vandy et al. [106], 100 % according to Michalinos et al. [107]). Therefore, a unanimous opinion emerged regarding the elective treatment of aneurysms of the gastropancreaticoduodenal arteries regardless of their size.

PICO 2.4.2 Clinical question: In patients with aneurysms of the gastropancreaticoduodenal arteries, which intervention/procedure is preferable in terms of outcomes?

Three reviews and three case series relative to the PICO question have recently been published. A first review from 2019 (Michalinos et al. [107]) underlines that the endovascular approach is characterised by a lower mortality and morbidity rate compared to the open treatment, even if technical success was similar. Furthermore, several procedures reveal that the endovascular treatment was proposed, when feasible, as the first-choice option, since it is characterized by a lower rate of complications, even if often subjected to a higher need for reinterventions [16, 109]. Vandy et al. report a very low mortality rate for patients with aneurysms of the gastropancreaticoduodenal arteries, relating it to the increasingly frequent use of endovascular treatments for incidentally found aneurysms [106]. Among the analysed studies, no one suggests the systematic revascularisation, either open or endovascular, of the coeliac artery when its stenosis is found as a possible aetiological cause of the aneurysm itself [108, 109]. On the other hand, the panel agrees in suggesting, as a good practice point, the revascularisation of the gastropancreaticoduodenal aneurysm when it is also associated with obstructive lesions affecting all three intestinal arteries (coeliac, superior and inferior mesenteric arteries). Finally, the authors agree in not contraindicating the use of the open surgical approach, although recognising the advantages of the endovascular technique, as already mentioned. In this sense, Bonardelli et al. [110] suggest a therapeutic approach to be customised according to the patient's characteristics, diagnosis, timing, and vascular anatomy.

PICO 2.4.3 Clinical question: In patients with pseudoaneurysms of the gastropancreaticoduodenal arteries, when is it justified to propose a surgical/endovascular treatment rather than medical therapy/follow up alone to improve the outcomes?

There are no randomised controlled trials responding to the PICO question. We identified two articles to make the recommendations, as they were adequate in terms of study design and responded to the PICO question. Specifically, a retrospective observational study [110] and a narrative review [111] were identified. They showed a weak scientific relevance (level of evidence 4) in relation to the study design and the few cases reported; therefore, the risk of bias might be considered. However, the studies are relevant for the target population and report similar results and conclusions. Although no relation has been reported between pseudoaneurysm size and risk of rupture, based on experts' opinions and on the aforementioned articles, both open and endovascular solutions are acceptable, in order to control bleeding in emergencies and to avoiding pseudoaneurysm rupture in the elective setting. The technical success of the interventions is satisfactory (90% for the endovascular treatment and 83% for the open treatment according to Bonardelli et al. [110]). Therefore, although with limited data, a unanimous opinion emerges regarding the need for treatment of pseudoaneurysms of the gastricopancreaticoduodenal arteries regardless of size, both in emergencies and electively. Clinical trials comparing treatment and surveillance of non-ruptured pseudoaneurysms are desirable in order to identify whether there is a size threshold or a morphologic aspect for which the treatment-related risks do not outweigh the risks of pseudoaneurysm ruptures.

PICO 2.4.4 Clinical question: In patients with pseudoaneurysms of the gastropancreaticoduodenal arteries, which intervention/procedure is preferable in terms of outcomes?

The literature research led to the selection of eight articles for the formulation of the recommendations, as they were adequate in terms of study design and responded to the PICO question. Specifically, five retrospective observational studies [110, 112-115], a narrative review [111], a case series [116] and a cohort study [117]. Overall, all of them had a low methodological relevance in terms of study design and number of cases, therefore biases might exist. Furthermore, some of the reported outcomes do not specifically refer to the target population but include more generic outcomes that consider pseudoaneurysms of visceral arteries. Despite that, the evaluated studies are relevant for the target population and report similar results and conclusions. As reported in a retrospective observational study from Bonardelli et al. [110], the endovascular treatment is to be preferred as a first approach if the location, size and anatomy of the vessel make the treatment feasible. Surgical treatment is to be preferred when the patient is haemodynamically unstable, if visceral resection is required, or in case the endovascular treatment is contraindicated or might have a high chance of failure. Referring to the narrative review by Kallamadi et al. [111], the endovascular treatment has some advantages, such as less invasiveness and complications than surgical treatment. It allows a better pseudoaneurysm evaluation and selective embolization, sparing other vessels. It can be associated with the treatment of celiac stenosis when present. However, as also stated by Murata et al. [115], the surgical treatment remains a viable option even after failure of endovascular treatment.

Gupta et al. [116] described some cases of bleeding gastropancreaticoduodenal arteries pseudoaneurysms in patients with chronic pancreatitis, suggesting that the endovascular treatment is indicated in most patients and may involve the use of thrombin if the aneurysm neck is narrow enough (less than 2 cm). Surgery is to be preferred depending on the location of the pseudoaneurysm and the underlying disease process. Clinical trials comparing surgical and endovascular treatment of ruptured pseudoaneurysms as well as electively treated pseudoaneurysms are still necessary to identify potential advantages of one over the other treatment options in terms of technical and clinical success.

2.5 HEPATIC ARTERY ANEURYSMS

PICO 2.5.1 Clinical question: In patients with aneurysms/pseudoaneurysms of the hepatic artery, when is it justified to propose a surgical/endovascular treatment rather than medical therapy/follow up alone to improve the outcomes?

According to literature, hepatic artery pseudoaneurysms account for 25% to 80% of reported cases and often occur after traumatic or iatrogenic traumas [118, 119]. Patient's clinical history and specific imaging findings allow to distinguish false aneurysms from true aneurysms. Imaging findings specific for pseudoaneurysms are focal arterial disruptions in a normal arterial setting and hematoma formation with inflammatory changes around the pseudoaneurysmatic sac. Most pseudoaneurysm cases are symptomatic at presentation with gastrointestinal bleeding and/or haemobilia, therefore differing from true aneurysm presentation [76]. Regarding pseudoaneurysm treatment, there are no randomized controlled trials, but only cohort studies are available. Due to a high propensity for rupture and significant disease-related mortality, treatment of all hepatic artery pseudoaneurysms is recommended, regardless of cause, as soon as diagnosed. Due to the rarity of these aneurysms, the natural history of hepatic artery aneurysms is unknown, making any recommendation for asymptomatic aneurysms controversial. The literature review process found mostly cohort studies, with low level of evidence given the retrospective setting. It was found that in the population with ruptured aneurysms the probability of rupture was higher when the diameter was >2 cm [38, 76, 118-123]. Abbas et al. observed that, in a retrospective cohort of 36 patients with hepatic artery aneurysm managed non-operatively for 68 months, aneurysms enlarged in only 27% of cases, without evidence of any complications [122]. Given the high morbidity and mortality rate after hepatic artery aneurysm rupture (30% mortality rate described in one series [122]) and the low morbidity and mortality rate after elective hepatic artery aneurysm repair (0% mortality rate described in the same study [122]), the elective treatment is recommended in patients with aneurysms >2 cm or with a high increasing size rate (>0.5 cm/years), having been taken into account patient's comorbidities and life expectancy. Stark et al. demonstrated a 10-times higher incidence of rupture in women when compared to the male population, with a low rate of clinically asymptomatic patients (19% women versus 81% men). Moreover, female patients that presented with hepatic artery aneurysm rupture were older (more than 60 years of age)

and with a mean aneurysm diameter of 2.5 ± 1.2 cm [120]. The presence of higher rupture rates in the female population requires indeed further investigations. Since hepatic artery aneurysms of non-atherosclerotic origin show higher rupture rate (incidence of 60% in patients with vasculitis and 50% in both Ehlers-Danlos syndrome type IV and alpha-1-antitrypsin deficiency patients), the elective treatment is recommended in patients with hepatic artery aneurysms even in case of diameters inferior to 2 cm [124, 125].

PICO 2.5.2 Clinical question: In patients with an aneurysm/pseudoaneurysm of the hepatic artery, which intervention/procedure is preferable in terms of outcomes?

Hepatic artery aneurysms can be treated both open and endovascularly. The literature review found two systematic reviews and several observational cohort studies. The reviewed studies showed comparable long-term outcomes when treating hepatic artery aneurysms through open and endovascular repair; however, postoperative morbidity was significantly worse in case of open rather than endovascular approach. Since endovascular techniques improved and the morbidity rates associated with this type of treatment were relatively lower, in case of favorable anatomy the endovascular option should be preferentially offered to patients [16, 126].

PICO 2.5.3 Clinical question: In patients with extra-hepatic aneurysms/pseudoaneurysms suitable for repair, is it preferable to maintain hepatic arterial circulation over endovascular vessel ligation/closure to avoid hepatic necrosis?

The literature review highlighted several systematic reviews and cohort studies, with a prevalence of observational studies. The ideal procedure should consist in aneurysm exclusion preserving liver circulation; this result could be obtained through stent-graft placement/coils embolization with endovascular exclusion of the aneurysm or by aneurysm resection and graft interposition. The use of stent-graft is mainly limited by anatomical factors, including a favorable anatomical setting that allows endovascular access to the aneurysm, an adequate "sealing zone" both proximal and distal and the absence of collateral pathways originating along or from the aneurysm itself [16, 126, 127]. In case of low-risk patients in which stent-graft placement might not be feasible, despite possible adequate collateral flow might be obtained through an endovascular exclusion as well, consider open surgical repair through autologous vein conduit to lower the chance of central necrosis [128]. In case of demonstrated patency of the pancreaticogastroduodenal arterial system, hepatic artery aneurysms located proximally to the origin of gastro-duodenal artery and to the right gastric artery could be considered for coil embolization with complete vascular exclusion of the main vessel [129].

PICO 2.5.4 Clinical question: In patients with intra-hepatic aneurysms/pseudoaneurysms suitable for repair, is it preferable the endovascular treatment over surgical lobe resection to preserve hepatic function?

The literature review found several systematic reviews and observational cohort studies. Intra-hepatic aneurysms require the resection of the entire lobe where the aneurysm is located; however, given the numerous comorbidities associated with liver resection surgery, an endovascular approach, if anatomically feasible, would be a valuable treatment strategy for this type of vascular lesions. Complications related to intra-hepatic artery aneurysm embolization include liver ischemia, abscess/biloma formation, cholecystitis and possible recanalization [16]. The endovascular treatment is not recommended in patient with giant aneurysms involving a whole liver segment and/or lobe, given the high chance of massive liver necrosis related to the endovascular treatment; in these patients, the hepatic resection should be considered [130].

2.6 MESENTERIC ARTERIES ANEURYSMS

PICO 2.6.1 Clinical question: In patients with a mesenteric artery aneurysm/pseudoaneurysm, when is it justified to propose surgical/endovascular treatment compared to medical therapy/follow-up alone to improve the outcomes?

Knowledge regarding the natural history of superior and inferior mesenteric artery aneurysms primarily derives from case series or retrospective cohort studies. There are no randomized studies comparing a conservative approach to corrective intervention. Another limitation of the existing literature is the frequent grouping of mesenteric artery aneurysms with cohorts of patients with aneurysms of other visceral arteries. Generally, the indication for surgical or endovascular treatment of a mesenteric artery aneurysm is justified when the risks associated with the natural history of the pathology (specifically, the risk of rupture) outweigh the risks associated with the intervention. True aneurysms of the mesenteric arteries can be asymptomatic or symptomatic with abdominal pain. Less common symptoms include nausea and gastrointestinal bleeding. The natural history of asymptomatic aneurysms is characterized by a tendency to increase in size potentially leading to rupture [131]. The evidence is consistent in concluding that the presence of asymptomatic true aneurysms of the superior or inferior mesenteric artery measuring >20 mm is an indication for treatment [131, 132]. One study [133] suggested using a cut-off diameter of 25 mm for intervention. Only one study conducted on a series of 21 superior mesenteric artery aneurysms suggested treatment regardless of size [134]. It is worth noting that recommendations regarding the cut-off diameter for treatment are primarily based on observations of the diameter of aneurysms that rupture at the time of presentation, as well as the high rate of major complications or mortality (38-58%) for emergency interventions compared to elective interventions (0-10%) [133, 134]. When comparing invasive treatment to monitoring, the analysed studies have a significant selection bias as larger aneurysms are predominantly treated. Furthermore, existing studies are unable to differentiate the natural history of saccular morphology aneurysms from fusiform ones. The presence of symptoms is usually associated with larger aneurysms, rapid growth, or rupture. Therefore, the presence of symptoms or signs of rupture represents a medical emergency that places the patient at immediate life-threatening risk and requires prompt correction. Mycotic aneurysms affecting the superior mesenteric artery are relatively common and are described in 15-20% of mesenteric artery aneurysm cases [133–135]. The most frequent cause is bacterial endocarditis. Dissecting aneurysms are characterized by isolated dissection of the superior mesenteric artery (SISMAD) [136], which can progress to artery dilation. Mycotic [137] and dissecting aneurysms are considered to be at higher risk of rupture than asymptomatic true aneurysms; therefore, treatment is warranted in all cases regardless of diameter. Pseudoaneurysms of the mesenteric arteries can result from inflammatory/infectious processes (e.g., acute pancreatitis), iatrogenic or accidental trauma. Pseudoaneurysms carry a higher risk of complications compared to true aneurysms, therefore their treatment is indicated in all cases regardless of size [135].

PICO 2.6.2 Clinical question: In patients with a mesenteric artery aneurysm/pseudoaneurysm, which intervention/procedure is preferable in terms of outcomes?

There are no randomised controlled trials in the literature comparing treatment strategies (open versus endovascular surgery) for mesenteric artery aneurysms. From the literature search, the meta-analysis and systematic review published by Barrionuevo et al.[16] was selected, which analyses 80 observational studies, with a total of 2845 visceral aneurysms and pseudoaneurysms of which 95 were of the superior mesenteric artery, 38 treated with endovascular approach, 57 with open surgery. Despite the small number of comparative studies, the data on short- and long-term mortality and perioperative complications are in favour of endovascular surgery as the first-line treatment choice. On the other hand, the rate of reinterventions was lower after open surgery. Five retrospective cohort studies [130, 133, 138-140] were identified, in overall agreement on results and conclusions: endovascular treatment is safe and effective, could be the treatment of choice in emergencies [139] and, when technically feasible, should be preferred as it is less invasive and associated with shorter hospital stays [140]. The literature search also identified nine observational studies/case series [92, 134, 137, 141-146] with low level of evidence, non-comparative and with small sample sizes; in some cases, the results reported aggregate data relating to all visceral aneurysms, not only specific for the mesenteric arteries. Despite these limitations, the studies tend to agree in their conclusions. The technique of choice in endovascular treatment should be left to the discretion of the operator: in the selected studies, the technical success was higher when using bare stent (dissecting aneurysm) [142], covered

stent, coiling, double lumen balloon-assisted [141] and overlapping bare metal stent [146]. Endovascular treatment and open surgery are both characterised by high technical success and all patients with aneurysm of the superior mesenteric artery fit for repair can be considered for surgery [134]. Open surgery (ligation, aneurysmectomy and bypass) has acceptable morbidity and mortality [137, 138] and can be considered in cases of unfavourable anatomy, failure of endovascular treatment and as primary treatment in mycotic aneurysms.

2.7 JEJUNAL, ILEAL AND COLIC ARTERIES ANEURYSMS

PICO 2.7.1 Clinical question: In a patient with an aneurysm/pseudoaneurysm of the jejunal, ileal or colic artery, when is surgical/endovascular treatment indicated versus medical therapy or watchful waiting to improve outcome?

Five of the six publications selected are narrative reviews [147-151], reporting clinical cases published in a very wide period ranging from 1937 to 2003. The observational study considered [152] includes patients treated from 1980 to 1998. No more recent publications including >5 patients responding to the PICO are available. Aneurysms of the colic arteries are the most commonly described (4 articles [147, 148, 150, 151] specifically for colic arteries); one article is specific for the jejunal arteries [149]; ileal aneurysms are described only in one publication [152]. Differentiation between aneurysms and pseudoaneurysms is difficult on the basis of the preoperative diagnostic investigations and some series do not differentiate them. In addition, the diameter of the aneurysm is not always reported. One article [148] includes all patients with segmental arterial mediolysis, while two other articles [147, 152] report more varied conditions: cystic dysplasia of the media, panarteritis nodosa, rheumatoid arthritis, Marfan syndrome, systemic lupus erythematosus, alpha-1 antitrypsin deficiency, tuberculosis. Colic aneurysms are the most reported (108 of 123), and several of them presented with rupture or shock regardless of their diameter.

PICO 2.7.2 Clinical question: In a patient with an aneurysm/pseudoaneurysm of the jejunal, ileal or colic artery, which intervention/procedure is preferable in terms of outcome?

The two publications considered are narrative reviews [147, 149], reporting clinical cases published over a very wide time period (from 1937 to 2002). There are no more recent publications including >5 patients responding to the PICO. Considering the lack of recent articles included in the study, endovascular treatment of aneurysms may be underestimated compared to its current use in clinical practice. The aneurysms considered are colic or jejunal [147, 149]; none of the included articles consider ileal aneurysms. Differentiation between aneurysms and pseudoaneurysms is difficult on the basis of preoperative diagnostic investigations and some series do not differentiate the two pathologies.

The endovascular procedure has the advantage of avoiding laparotomy, thus for its lower invasiveness, it potentially reduces complications. For jejunal and colic aneurysms, the endovascular intervention could avoid procedures of bowel resection and its complications if the aneurysm develops in the proximity of the bowel wall. In the considered literature [147, 149], no deaths were reported in the cases treated with endovascular techniques (0 of 7), while 3 of 39 patients died after open surgery. Although these data are scarce, they stress the less invasiveness of the endovascular treatment.

2.8 ISOLATED HYPOGASTRIC ARTERY ANEURYSMS

PICO 2.8.1 Clinical question: In patients with an isolated hypogastric artery aneurysm, when the endovascular/surgical treatment strategy is justifiable, instead of the conservative management/follow-up, to improve the outcomes?

The systematic review of the literature did not provide any prospective cohort study which investigated the natural history of isolated hypogastric artery aneurysms focusing in particular on their risk of rupture related to diameter or growth rate.

Traditionally, the threshold for treatment was 3 cm of diameter, following some observational studies that reported no ruptures for diameters below that value. However, those studies did not discriminate between aneurysms of the common iliac, external iliac or hypogastric arteries, or between isolated aneurysms or aneurysms associated with other iliac or abdominal aortic segments. This selection bias is common to most of the studies identified [153-173], which provided surrogate data, being the information on diameters and rupture risk of isolated hypogastric artery aneurysms scarce and not easily extractable. In a study by Richardson et al. [153], the authors indeed took generically into account aneurysms of the iliac arteries, and described as "aneurysm" dilatations with a diameter of 2.5 cm or above, not explaining the rationale behind this choice. Regarding the size cut-off between the elective treatment and the follow-up, the diameter set as reference in the discussion is still indicated at 3 cm. A study from Kliewer et al. [154] instead, examined patients with aneurysms of the hypogastric artery alone, isolated or in association with other aneurysms, and among the inclusion criteria there was a diameter of 1.6 cm or above, still not providing reasoning for this choice. Anyway, the authors stated that 1.6 cm was not the suggested cut-off for treatment indication, as they concluded that the critical dimensions were between 3 and 4 cm (the mean diameter of aneurysms treated in their study was 38.2 mm indeed). Smaller aneurysms were treated during the same endovascular procedure only if in association with aorto-iliac aneurysms. Considering the definition of a true arterial aneurysm as a permanent dilatation of a vessel above 50% of its normal diameter, the studies cited above [153, 154] demonstrate how a bias could still exist in the definition of aneurysm when it is isolated to the hypogastric artery. The reference measurements are in fact borrowed from other iliac districts, particularly from the common iliac artery that has an average diameter of about 1 cm, whereas for the hypogastric artery it is commonly 0.5 cm. In other two studies (Gao et al. [155] and Muradi et al. [156]) investigating isolated hypogastric artery aneurysms, the key-points considered indications for an elective treatment were: diameter of 3 cm or above and rapid growth, and a critical growth was considered as being an increase of 0.5 cm in size in 6 months [155, 156], or 1 cm in 12 months [156]. These studies did not specify their rationale, as they just cited prior publications which almost exclusively included common iliac arteries aneurysms; hence, their conclusions are not applicable for the hypogastric arteries as well. A study from Laine et al. [157] included patients with isolated hypogastric artery aneurysms and other dilatations of the aorto-iliac axis, aiming to explain which the diameter of rupture of these aneurysms was and if it was proper considering 3 cm as being the cut-off. It was a retrospective analysis on 63 patients from 28 hospitals in 7 different countries. In this cohort, only 18 patients had an isolated hypogastric artery aneurysm, and all the patients were treated for a ruptured aneurysm of the hypogastric artery. The mean diameter of the ruptured aneurysms was 6.8 cm, with no significant difference between men and women. Considering only hypogastric artery aneurysms rupture, the mean diameter was 6.1 cm, while the diameter of non-isolated aneurysms of the hypogastric artery was 7.2 cm. The authors reported only one case of rupture with a diameter below 3 cm (1.6% of all ruptured aneurysms) and four cases with a diameter of less than 4 cm (6% of all ruptured aneurysms). Moreover, the reported 30-day mortality rate was 12.7%. Results from this study indicated that the risk of rupture of isolated hypogastric artery aneurysms of less than 4 cm of diameter could be similar to those of abdominal aortic aneurysms with a diameter less than 5.5 cm. However, an important difference emerged: data about abdominal aortic aneurysms come from multiple randomized control studies, with a level of evidence 1; whereas in this case we have a level of evidence 3. The authors emphasized how heterogeneous the measurements of aneurysm diameters were at the time of rupture, thus maybe underestimating the real dimensions compared to measurements taken pre-rupture. This condition suggested a less aggressive approach in the management of isolated hypogastric artery aneurysms, in which the treatment could be postponed until the diameter reaches 4 cm, which might be considered safe especially in elderly patients with a higher surgical risk. In a recent retrospective cohort study (Chen Rj et al. [158]) conducted on 23 patients with 31 hypogastric artery aneurysms, of whom 6 isolated hypogastric artery aneurysms, the authors reported that 4 out of 5 ruptured aneurysms showed a diameter greater than 4 cm, not specifying if this applied to isolated or combined aneurysms. Moreover, 6 aneurysms which were followed up during time showed an average annual growth rate of 2.4 mm. However, these data are not enough to motivate a less aggressive approach towards aneurysms within 4 cm of diameter, and to draw conclusions about their annual growth rate, because the annual growth rate sets around 1-4 mm/year, matching the growth rate shown by abdominal aortic aneurysms. The recent meta-analysis by Perini et al.[174], analyzing studies dealing specifically with isolated hypogastric artery aneurysms (overall 192 patients with 202 aneurysms) applied the definition of aneurysm as a dilatation with a diameter of at least 0.8 cm. From this meta-analysis emerged the recommendation for a conservative management in case of patients with aneurysms of less than 3.5 cm diameter and less than 4 cm in the elderly. In those cases with a diameter of less than 3 cm, treatment might be considered only in young subjects and those patients with concomitant indication for other aorto-iliac aneurysms.

PICO 2.8.2 Clinical question: Which is the type of intervention/procedure to be preferred for patients with isolated hypogastric artery aneurysms?

Even if current literature is limited in terms of numbers, procedural standardization and outcomes (results of isolated iliac aneurysms, common iliac and hypogastric arteries are usually reported indistinctly), the endovascular solution represents

the first treatment option since it offers a higher technical success as well as better early and mid-term clinical success than open surgery. In a recent systematic literature review and meta-analysis, Perini et al. [174] analyze the results of 13 studies on surgical or endovascular repair of isolated hypogastric artery aneurysms. Out of 193 patients and 202 aneurysms 202, the results after endovascular and open repair were comparable in terms of technical success (open: 95% versus endovascular: 90%) with an overall incidence of buttock claudication of 14%. However, this complication was not reported in case of endovascular aneurysm repair consisting of hypogastric artery revascularization. Endovascular repair was associated to lower perioperative mortality (open: 8% versus endovascular: 3%) and shorter hospital stay (mean days: 0pen 13 versus endovascular 4) than open repair. The endovascular repair of isolated hypogastric artery aneurysms can be considered safe and effective even in emergency setting. In a single-center experience, Kobe et al. [159] reported that the endovascular approach can be considered the first technical choice even in cases of hypogastric aneurysm rupture. Obviously, according to their clinical presentation, results may differ in case of urgent clinical settings, in terms of technical success (elective: 100% vs urgent: 84%) and need for conversion to open surgery (4% only in urgent cases). Similar considerations can be summarized from the experience of Rana et al. [160], which reported the results of surgical and endovascular repair of hypogastric artery aneurysms analyzing both urgent and elective scenarios. According to this experience, the endovascular repair had lower perioperative mortality (open: 2% versus endovascular: 0%), morbidity (open: 43% versus endovascular: 8%) and shorter hospitalizations (mean days: open 9 versus endovascular 1). The elective repair had a lower morbidity in terms of cardiological complications and bowel ischemia. The low invasiveness of endovascular repair was also reported by Patel et al. [171] and Chaer et al. [172]. Both these single-center experiences demonstrated that the endovascular repair of an isolated hypogastric artery aneurism is associated with lower hospitalization and need of blood infusion than open surgical repair. Finally, several endovascular technical options were reported for both hypogastric embolization and revascularization [174]. Distal hypogastric artery revascularization was associated with a lower incidence of buttock claudication than proximal one [174]. In case of hypogastric artery embolization, the embolization of all distal aneurysm branches was associated with higher freedom from post-treatment aneurysm growth and reinterventions [156].

3. MEDICAL THERAPY AND FOLLOW-UP

PICO 3.1 Clinical question: In patients with visceral or renal artery aneurysms who underwent corrective open/endovascular treatment, is CT angiography/Magnetic Resonance angiography superior to Doppler Ultrasound (DUS) for follow-up surveillance?

Literature research did not highlight randomized controlled trials, meta-analyses or observational studies correspondent to the PICO of interest, therefore recommendations relied on experts' opinion and current clinical practice. In case of patients treated endovascularly, it was established that CT angiography examinations should be performed within 3 months from index procedure and subsequently at 12 months to identify possible endoleaks or sac volume increase that might lead to aneurysm rupture. In case of open surgical treatment, CT angiography examination is suggested within 3 months from surgery and subsequently at 12 months; if no complications develop at 12 months, no further follow-up would be suggested.

PICO 3.2 Clinical question: In patients with visceral or renal artery aneurysms who did not undergo corrective treatment, is CT angiography/Magnetic Resonance angiography superior to Doppler Ultrasound (DUS) for aneurysm dimensions surveillance?

Literature research did not highlight randomized controlled trials, meta-analyses or observational studies correspondent to the PICO of interest, therefore recommendations relied on experts' opinion and current clinical practice. Considering the slow growth rate of these aneurysms, an annual DUS examination is suggested. In case of unfavorable anatomies which do not allow adequate ultrasound evaluation, it would be suggested to consider CT angiography or Magnetic Resonance angiography. It would be suggested to extended surveillance period up to 24-36 months in case of demonstrated volumetric stability.

PICO 3.3 Clinical question: In patients with visceral or renal artery aneurysms who did not undergo corrective treatment, is home medical therapy optimization indicated, compared to no therapy, to improve outcomes?

Literature research did not highlight randomized controlled trials, meta-analyses or observational studies correspondent to the PICO of interest, therefore recommendations relied on experts' opinion and current clinical practice. It was suggested to optimize medical therapy according to the etiopathogenetic cause of the aneurysm. Therefore, in patients with atherosclerotic visceral and/or renal artery aneurysms, modifiable risk factors treatment would be advisable, as well as medical therapy optimization according to current guidelines on atherosclerosis [175-177]. In patients with non-atherosclerotic non-inflammatory aneurysms (degenerative, connective tissue disorders or congenital diseases) antihypertensive therapy optimization and smoking cessations are desirable. In case of connective tissue disorders, antiplatelet therapy is suggested. In patients with visceral and/or renal artery inflammatory aneurysms, the use of steroids and/or immunosuppressants would be suggested to control inflammatory processes.

PICO 3.4 Clinical question: In patients with visceral or renal artery aneurysms who underwent corrective open/endovascular treatment, is home medical therapy optimization indicated, compared to no therapy, to improve outcomes?

Literature research did not highlight randomized controlled trials, meta-analyses or observational studies correspondent to the PICO of interest, therefore recommendations relied on experts' opinion and current clinical practice. It was suggested to optimize medical therapy according to the etiopathogenetic cause of the aneurysm. Therefore, in patients with atherosclerotic visceral and/or renal artery aneurysms, modifiable risk factors treatment would be advisable, as well as medical therapy optimization according to current guidelines on atherosclerosis [175-177]. In patients with non-atherosclerotic non-inflammatory aneurysms, antihypertensive therapy optimization and smoking cessations are desirable. In case of open surgical treatment, there is no evidence regarding the use of antiplatelet or anticoagulant therapy while, in case of endovascular treatment, it is suggested to evaluate short or long-term antiplatelet therapy according to the type of device used. Additionally, antiplatelet therapy might be considered for patients with connective tissue disorders. In patients with visceral and/or renal artery inflammatory aneurysms, the use of steroids and/or immunosuppressants would be suggested both in the pre- and post-operative surgical or endovascular period to control inflammatory processes.

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