

Appendix E1.

Table E1. Recommendations for pulmonary hypertension expert referral centers

Recommendations	Class ^a	Level ^b
It is recommended for referral centers to provide care by a multiprofessional team (cardiology and respiratory medicine physicians, clinical nurse specialist, radiologists, psychologic and social work support, appropriate on-call expertise)	I	C
It is recommended for referral centers to have direct links and quick referral patterns to other services (such as CTD, family planning, PEA, lung transplantation, adult congenital heart disease)	I	C
It should be considered that a referral center follow at least 50 patients with PAH or CTEPH and should receive at least two new referrals per month with documented PAH or CTEPH	Ila	C
It should be considered that a referral center perform at least 20 vasoreactivity tests in IPAH, HPAH or DPAH patients per year	Ila	C
Referral centers should participate in collaborative clinical research in PAH, including phase II and phase III clinical trials	Ila	C

Reprinted, with permission, from reference 7. CTD: connective tissue disease; CTEPH: chronic thromboembolic pulmonary hypertension; DPAH: drug-induced pulmonary arterial hypertension; HPAH: heritable pulmonary arterial hypertension; IPAH: idiopathic pulmonary arterial hypertension; PAH: pulmonary arterial hypertension; PEA: pulmonary endarterectomy.

^aClass of recommendation.

^bLevel of evidence.

Table E2. MRI biomarkers found to be predictive of survival in patients with pulmonary hypertension

First Author (year published) (reference)	Cohort Size (n)	CMR metric	Hazard Ratio	Hazard Ratio 95%C.I.	P value	Analysis	Cutoff (Kaplan-Meier)
Gan (2007) (73)	70	PA RAC	0.87	0.79–0.96	0.006	univariate	16%>
van Wolferen (2007) (74)	64	SVI	0.764		<0.001	multivariate	25 mL/m ² >
		RVEDVI	1.61		<0.001		84 mL/m ² <
		LVEDVI	0.705		0.002		40 mL/ms >
van de Veerdonk (2011) (75)	110	RVESVI	1.014	1.001–1.027	0.048	univariate	
		RVEF	0.938	0.902–0.975	0.001		35%>
		LVEDVI	0.962	0.931–0.994	0.019		
		LVESVI	0.942	0.888–0.998	0.045		
		SVI	0.945	0.899–0.993	0.025		
Freed (2012) (76)	58	RVEF	0.91	0.83–0.99	0.036	multivariate	39%>
Yamada (2012) (77)	41	RVEDVI	1.03	1.00–1.05	0.02	multivariate	
Baggen (2016) (78)	539	RVEF	1.23	1.07–1.41	0.003	meta-analysis	
		RVEDVI	1.06	1.00–1.12	0.049		
		RVESVI	1.05	1.01–1.09	0.013		
		LVEDVI	1.16	1.00–1.34	0.045		
de Siqueira (2016) (79)	110	GLS	1.06	1–1.12	0.026	multivariate	–17%<
		RVEF	0.97	0.94–0.99	0.03		
		GLSR	2.52	1.03–6.1	0.04		–1.1 S ^{–1} <
		GCSR	4.5	1.3–15.6	0.01		–0.8S ^{–1} <
Swift (2017) (80)	576	RVESV	1.217	1.061–1.539	0.005	multivariate	180 mL >
		PA RAC	0.762	0.623–0.932	0.008		

Abbreviations: CMR = cardiac magnetic resonance imaging; C.I.= Confidence interval; PA RAC = pulmonary artery relative area change; SVI = stroke volume index; RVEDVI = right ventricular end-diastolic volume index; LVEDVI = left ventricular end-diastolic volume index; RVESVI = right ventricular end-systolic volume index; RVEF = right ventricular ejection fraction; LVESVI = left ventricular end-systolic volume index; RVESV = right ventricular end-diastolic volume; LVSV = left ventricular stroke volume; FWHM = full width at half maximum; PTT = pulmonary transit time; GLS = global longitudinal strain; GLSR = global longitudinal strain rate; GCSR = global circumferential strain rate.

Appendix E2: Methods

We excluded studies using either transthoracic or transesophageal echocardiography to define PH. Comprehensive and systematic literature search strategies were designed for each question using medical subject headings and text words. Searches were limited to English for 2008 through August 2018 in MEDLINE, Embase, and Cochrane Central Register of Controlled Trials (CCTR) and Health Technology Assessment (HTA).

One committee member (MRJ) conducted a prescreening of the initial search results, removing duplicate citations and publications unrelated to PH. A lead author was identified for each key question, who was responsible for assessing eligibility criteria for all publication titles that passed the prescreening assessment. In two distinct stages, two committee members then independently reviewed the abstracts and full-text articles to identify publications relevant to each key question. Eligibility criteria included original research using any study design, a sample size of ³ 10 adults with PH confirmed by right heart catheterization (RHC), and publication in English. A brief narrative summary was created for each eligible article as it related to each key question, which was then provided to the working group to support writing and referencing of the final position paper. A formal quality of evidence assessment was not performed given the heterogeneity of study design and the fact that some of the identified literature did not pertain to the key questions. Important articles published before and after the date range of this original search were referenced where appropriate, but these were not part of the formal systematic review. Search strategies are available in Appendix E7. The initial search identified 5163, 4737, 5163, 5288, 1390 and 2123 publications for each of the six key questions, respectively. From these, 388 unique publications met the eligibility criteria and were relevant to at least one key question. The working group reviewed these publications and used them to support creation of the final document.

Appendix E3: Practical Considerations for Assessing PH in the Clinic

The symptoms of PH are nonspecific (including exertional dyspnea, fatigue, weakness, chest pain, light-headedness/syncope). Progressive right-sided heart failure (characterized by edema, ascites, abdominal distension) tends to occur later in the course of the disease. Rarely, hemoptysis, Ortner's syndrome/hoarseness (left-sided vocal cord paralysis) and arrhythmias may occur. Physical findings include jugular venous distension, hepatomegaly, hepato-jugular reflux, right ventricular lift, ascites, edema, tricuspid regurgitation or pulmonary regurgitation murmurs, loud second heart sound and S3 gallop. ECG may show abnormalities compatible with PH such as right bundle branch block or right axis deviation (but a normal ECG does not exclude PH). As a general rule, patients presenting with unexplained shortness of breath should be further evaluated, in particular by echocardiography, to investigate the probability of PH. The pretest probability is higher in patients with conditions known to be associated with PH such as connective tissue disease (typically systemic sclerosis, mixed connective tissue disease and systemic lupus erythematosus), portal hypertension and HIV infection. The same applies for CTEPH, a severe form of PH affecting 1 to 3% of acute pulmonary embolism (PE) survivors. In that setting, persistent dyspnea and functional limitation following an episode of acute PE should raise the suspicion of CTEPH and prompt specific assessment.

The development of precapillary PH is common in parenchymal lung diseases and associated with aggravated symptoms and poor outcomes. Symptoms and physical signs of PH may be difficult to identify in patients with respiratory disorders. The PH diagnostic approach is

multidisciplinary with an emphasis on the clinical probability of PH and the detection of imaging characteristics suggesting PH, prompting the decision to perform echocardiography followed by RHC when appropriate, ie, when therapeutic benefit is anticipated. As a general rule, patients presenting with symptoms that are more severe than expected based on their pulmonary function test results should be further evaluated, in particular by echocardiography, to search for concomitant left heart disease and/or PH. In addition, all respiratory diseases for which lung transplantation is considered should have a meticulous evaluation of possible comorbid PH. In this context, PH may be clinically suspected if there is persistent dyspnea despite adequate therapy of the respiratory condition and/or clinical signs of right heart failure. Clinical judgement is critical to assess the likelihood of PH in patients with comorbid respiratory diseases. In this setting, the probability of PH is higher if there is (i) persistent decline in 6-minute walk distance with marked oxygen desaturation at exercise and/or decline in diffusing lung capacity for carbon monoxide (DLCO)/carbon monoxide transfer coefficient (KCO) without modification of lung function tests; (ii) an increased oxygen requirements in the course of the disease; (iii) elevation of brain natriuretic peptide (BNP) or *N*-terminal probrain natriuretic peptide (proBNP); (iv) the ECG shows abnormalities compatible with PH. CT measures of PA and right-heart chambers may increase the likelihood of PH and further support to the need for echocardiography (Fig E1). While increased PA diameter should alert to the possibility of PH, a normal PA diameter does not exclude PH (Fig E2).

Appendix E4: Diagnostic Approach to PH: An Evolving Schema

The diagnostic approach to PH is a multiparametric consideration. In service to the patient and financial considerations, the use of multiple imaging modalities should be minimized. This is best accomplished by informed physicians who can recommend the most efficient and effective sequence for diagnostic testing. The diagnostic strategy will depend on the degree of suspicion for PH. When PH has not been recognized, the patient is usually referred for the evaluation of nonpecific symptoms (ie, unexplained dyspnea). The first-line imaging test is often a noncontrast chest CT examination; a frequent alternative is chest CTA for a comprehensive analysis of cardiopulmonary structures, both obtained with thin (< 1 mm) sections. When PH is suspected with high probability at echocardiography or has already been confirmed by RHC, two approaches may be considered. The traditional approach follows current recommendations with a central role for V/Q scintigraphy (CTEPH versus non-CTEPH patients), followed by CTA in CTEPH patients (Group 4 PH) or noncontrast CT for other etiologies (ie, group 1, group 3, group 5 PH). An alternative approach implemented in some centers (8,71,72) is to condense the evaluation by replacing V/Q scintigraphy with a single-energy CT angiogram. When available, dual-energy CT augments morphologic information with perfusion, but more evidence regarding the utility of dual-energy CT derived perfusion is needed, especially in the challenging cases such as distal CTEPH. Although the lack of ionizing radiation makes MR an interesting diagnostic method, limited availability and higher costs currently preclude the use of MR in the diagnosis of CTEPH unless iodinated contrast material is contraindicated.

Appendix E5: What Are the Perspectives in the Field of Imaging of Pulmonary Hypertension?

1. Early Diagnosis of PH

In a recent study, Bergemann et al reported high levels of activity and frequent contacts with health care services in the three years before a confirmed diagnosis of iPAH (139). In addition, patients frequently sought attention from respiratory and cardiology specialists. The combination of high levels of activity and the richness of specialty interactions raises the possibility that patients with iPAH may exhibit characteristic patterns of behavior separate from other cardiorespiratory conditions, providing sufficient data to support the development of a predictive diagnostic algorithm for iPAH. The authors are currently engaged in a big-data approach, utilizing a model based on artificial intelligence to develop a predictive algorithm to screen for patients with undiagnosed iPAH in the general population. It remains to be seen how and where imaging may complement early PH detection programs.

2. Noninvasive Pulmonary Artery Pressure Assessment

Current methods to assess PH rely on indirect consequences of raised pulmonary vascular resistance at the level of the right ventricle and proximal pulmonary artery while morphologic assessment of small vascular sections on unenhanced CT can also play a role as described in COPD. Increasing implementation of 4D flow analysis allows for the noninvasive assessment of flow through the pulmonary artery, where the presence of vortices and duration of vortices has been shown to be diagnostic for PH (41). This application is an active focus in MR development. High diagnostic accuracy has been shown for pulmonary arterial hypertension based on a tensor-based machine learning approach (140). Combined automated 3D volumetry of the central pulmonary arteries by pulmonary CT angiography and echocardiographic pressure estimate has recently been reported as an interesting approach to predict the presence of pulmonary hypertension (141). Machine learning by using cardiac MRI could also be used as a tool to guide patient management (142).

3. Detection of Small-Vessel Vasculopathy

Alterations of lung microcirculation can be depicted morphologically on HRCT lung images (eg, in the context of PVOD) or estimated on the basis of perfusion defects on perfusion scintigraphy, dual-energy or MR perfusion images. However, none of these techniques can provide fine analysis of the most distal compartment of the pulmonary circulation, and thus prevent imaging from participating in the confident depiction of diagnostic (eg, PAH) or prognostic (eg, microvasculopathy in CTEPH) features.

Technological developments such as photon counting CT as well as machine-learning approaches should open new possibilities in the analysis of distal parts of the pulmonary circulation.

4. Automated Depiction of Vascular Changes in CTEPH

CTEPH assessment is challenging at several steps. It is sometimes difficult to depict features of chronic PE on CT, which can be responsible for a long delay in diagnosis. The pretherapeutic assessment of CTEPH requires a meticulous and time-consuming analysis of arterial branches

for proper description of all abnormalities that will be shared with the surgeon for therapeutic accessibility. In both situations, an automated approach to analyzing CTEPH morphologic features and a simplified view of the arterial tree could be particularly helpful.

Appendix E6: Key Messages

Question No. 1: “Is Noninvasive Imaging Capable of Identifying Pulmonary Hypertension?”

- PA diameter cannot be used as a stand-alone criterion for PH
- A normal PA diameter does not exclude PH
- Increased PA diameters should alert to the possibility of PH in the context of:
 - normal lung parenchyma
 - mild features of lung infiltration (ILD) or bronchopulmonary changes (COPD)
 - persistent dyspnea and/or functional decline after acute pulmonary embolism
 - patients with a high pre-CT probability of PH
- When PH is already highly suspected by echo or confirmed by RHC, PA measurements are not clinically relevant, except in presence of PA aneurysmal dilatation (> 40 mm).

Question No. 2: “What Is the Role of Imaging in Establishing the Cause of Pulmonary Hypertension?”

- Per current guidelines, V/Q lung scan is the recommended investigation in PH patients to rule out CTEPH.
- Single-energy CT can provide diagnostic information on PH etiology and should play a more important role in the diagnostic strategy.
- Dual-energy CT combines morphologic information with lung perfusion (ie, iodine maps) which has the potential of increasing CT diagnostic capabilities.
- MR is not a first-line diagnostic imaging modality but can provide complementary information to echocardiography and CT.

Question No. 3: “How Does Imaging Determine the Severity and Complications of Pulmonary Hypertension?”

- CMR can track the longitudinal changes of ventricular function after therapy for PH.
- CMR metrics of ventricular function are predictive of survival in patients with PH.
- Coronary artery CT angiography may demonstrate flow-limiting left main coronary artery compression in PH patients

Question No. 4: “How Should Imaging Be Used to Assess Chronic Thromboembolic Pulmonary Hypertension before Treatment?”

- Individualized approach to CTEPH treatment with different strategies (surgical, medical and/or interventional) should be discussed in experienced institutions with multidisciplinary teams.
- Besides lifelong anticoagulation, pulmonary endarterectomy is the treatment of choice in patients with proximal obstructing lesions; for inoperable cases, medical therapy is recommended with or without balloon pulmonary angioplasty.
- Digital subtraction angiography, previously considered as the gold standard, has been largely replaced by noninvasive modalities; CT angiography can be used for assessment of operability and balloon pulmonary angioplasty.
- With advances in distal pulmonary endarterectomy and balloon pulmonary angioplasty, and a more general focus on more distal vascular assessment, selective segmental angiography, cone-beam CT and ECG-gated CT may also be considered for precise delineation of distal pulmonary vessels.

Question No. 5: “Should Imaging Be Performed after Treatment of Pulmonary Hypertension?”

- Patients with CTEPH who have undergone PEA and are asymptomatic with normalized or near normalized pulmonary hemodynamics do not require follow-up imaging.
- In patients with CTEPH who remained symptomatic with residual PH after PEA, the key question is whether residual pulmonary vascular occlusions are amenable to BPA; conventional DSA or cone-beam CT are the most widely used techniques to address this question.
- MRI is increasingly being used to assess cardiac function and regional lung perfusion in patients with CTEPH before and after therapy.
- Cardiac MRI has become the gold standard to determine RV function in patients with PH of various etiologies and several MRI-derived variables, such as RVEF, provide independent prognostic information.

Appendix E7: Search Strategy

Table E3. Systematic review search strategy overview

Question	Search strategy overview
1	PH & (CT or MRI)
2	PH & (CT or scintigraphy) & (CTEPH or PVOD or PCH)
3a	PH & (CT or MRI)
3b	PH & (CT or MRI or scintigraphy)
4	CTEPH & (CT or MRI or pulmonary angiography)
5	CTEPH & (surgery or balloon pulmonary angioplasty)

Abbreviations: CT: computed tomography; CTEPH: chronic thromboembolic pulmonary hypertension; MRI: magnetic resonance imaging; PCH: pulmonary capillary hemangiomatosis; PH: pulmonary hypertension; PVOD: pulmonary veno-occlusive disease.

Table E4. MEDLINE search strategy for question 1

Question 1: Is noninvasive imaging capable of identifying pulmonary hypertension?		
Row	Search terms	Number citations
1	hypertension, pulmonary/or familial primary pulmonary hypertension/	31804
2	((pulmonary or lung) adj3 hypertensi\$).mp.	48785
3	(pulmonary adj2 (heart or vascular or arter\$ or cardiac) adj2 disease\$).mp.	9773
4	(corpulmonale or cor pulmonale).mp.	4020
5	1 or 2 or 3 or 4	55766
6	magnetic resonance imaging/or diffusion magnetic resonance imaging/or echo-planar imaging/or ¹⁹ F magnetic resonance imaging/or magnetic resonance angiography/or magnetic resonance imaging, cine/	396478
7	(MRI or MRIs or (magnet\$ adj2 (transfer or resonance) adj2 (tomogra\$ or imag\$ or angiogra\$)) or ((MR or NMR) adj imag\$)).mp.	528834
8	(echo adj2 (planar or spin) adj2 imag\$).mp.	8319
9	6 or 7 or 8	529782
10	tomography, x-ray computed/or computed tomography angiography/or four-dimensional computed tomography/	355357
11	((electrocardiogra\$ or ECG\$) adj2 (gated or synchroni\$)).mp.	2710
12	((computer\$ adj2 (assisted or diagnos\$)) or CT scan\$ or ((positron or compute\$ or emission) adj3 tomograph\$) or tomoscintigra\$ or PET scan\$ or (CT adj2 (scan\$ or angiogra\$ or dual-energy))).mp.	849613
13	11 or 12	850311
14	10 or 13 [CT]	850311
15	9 or 14	1202294
16	5 and 15	3517
17	limit 16 to English language	3046
18	limit 17 to yr = "2008-Current"	2210
19	limit 18 to (comment or editorial or letter)	97
20	18 not 19	2113

Table E5. EMBASE search strategy for question 1

Question 1: Is noninvasive imaging capable of identifying pulmonary hypertension?		
Row	Search terms	Number citations
1	hypertension, pulmonary/or familial primary pulmonary hypertension/	40563
2	((pulmonary or lung) adj3 hypertensi\$).mp.	72621
3	(pulmonary adj2 (heart or vascular or arter\$ or cardiac) adj2 disease\$).mp.	6051
4	(corpulmonale or cor pulmonale).mp.	2721
5	1 or 2 or 3 or 4	76921

6	exp nuclear magnetic resonance imaging/	774826
7	((MRI or MRIs or (magnet\$ adj2 (transfer or resonance) adj2 (tomogra\$ or imag\$ or angiogra\$)) or ((MR or NMR) adj imag\$)).mp.	797608
8	(echo adj2 (planar or spin) adj2 imag\$).mp.	8269
9	6 or 7 or 8	827600
10	exp computer assisted tomography/	807433
11	((electrocardiogra\$ or ECG\$) adj2 (gated or synchroni\$)).mp.	3633
12	((computer\$ adj2 (assisted or diagnos\$)) or CT scan\$ or ((positron or compute\$ or emission) adj3 tomograph\$) or tomoscintigra\$ or PET scan\$ or (CT adj2 (scan\$ or angiogra\$ or duel-energy\$)).mp.	956339
13	11 or 12	957338
14	10 or 13 [CT]	960662
15	9 or 14	1549245
16	5 and 15	10802
17	limit 16 to English language	10167
18	limit 17 to yr = "2008-Current"	8908
19	limit 18 to (conference abstract or editorial or erratum or letter or note)	3593
20	18 not 19	5315
21	limit 20 to (adult < 18 to 64 years > or aged < 65+ years >)	3050

Table E6. MEDLINE search strategy for question 2

Question 2: What is the role of imaging in establishing the cause of pulmonary hypertension?		
Row	Search terms	Number citations
1	hypertension, pulmonary/or familial primary pulmonary hypertension/	31863
2	((pulmonary or lung) adj3 hypertensi\$).mp.	48909
3	(pulmonary adj2 (heart or vascular or arter\$ or cardiac) adj2 disease\$).mp.	9781
4	(corpulmonale or cor pulmonale).mp.	4022
5	1 or 2 or 3 or 4	55890
6	tomography, x-ray computed/or computed tomography angiography/or four-dimensional computed tomography/	356201
7	((electrocardiogra\$ or ECG\$) adj2 (gated or synchroni\$)).mp.	2713
8	((computer\$ adj2 (assisted or diagnos\$)) or CT scan\$ or ((positron or compute\$ or emission) adj3 tomograph\$) or tomoscintigra\$ or PET scan\$ or (CT adj2 (scan\$ or angiogra\$ or duel-energy\$)).mp.	851580
9	7 or 8	852278
10	6 or 9 [CT]	852278
11	radionuclide imaging/or radionuclide angiography/or exp radionuclide ventriculography/[Medline]	91107
12	(scintiscan\$ or scintillogr\$ or scintigra\$ or scintillation).mp.	59935
13	(radionuclide adj2 (imag\$ or angiogra\$ or ventriculogra\$)).mp.	92250
14	positron emission tomography computed tomography/or single photon emission computed tomography computed tomography/	4654
15	11 or 12 or 13 or 14	129972
16	10 or 15 [CT or Scintigraphy]	953886
17	5 and 16 [PH and imaging]	3366
18	(CTEPH or (((thromboemboli\$ or thrombo-emboli\$) adj2 (pulmonary adj2 hypertensi\$)) or disease\$ or chronic)).mp.	6299745
19	pulmonary veno-occlusive disease/	758
20	((lung or pulmonary) adj2 (venoocclusi\$ or veno-occlusi\$)).mp.	959
21	19 or 20	959
22	(pulmonary adj2 capillary adj2 h\$emangiomatosis).mp.	114
23	18 or 21 or 22 [CTEPH or PVOD or PCH]	6299778
24	17 and 23	2327
25	limit 24 to English language	1844
26	limit 25 to (comment or editorial or letter)	37

27	25 not 26	1807
28	limit 27 to yr = "2008-Current"	1102

Table E7. EMBASE search strategy for question 2

Question 2: What is the role of imaging in establishing the cause of pulmonary hypertension?		
Row	Search terms	Number citations
1	hypertension, pulmonary/or familial primary pulmonary hypertension/	40747
2	((pulmonary or lung) adj3 hypertensi\$).mp.	72849
3	(pulmonary adj2 (heart or vascular or arter\$ or cardiac) adj2 disease\$).mp.	6072
4	(corpulmonale or cor pulmonale).mp.	2724
5	1 or 2 or 3 or 4 [PH]	77162
6	exp computer assisted tomography/	810146
7	((electrocardiogra\$ or ECG\$) adj2 (gated or synchroni\$)).mp.	3642
8	((computer\$ adj2 (assisted or diagnos\$)) or CT scan\$ or ((positron or compute\$ or emission) adj3 tomograph\$) or tomoscintigra\$ or PET scan\$ or (CT adj2 (scan\$ or angiogra\$ or dual-energy))).mp.	959285
9	7 or 8	960287
11	6 or 9 [CT]	963626
12	scintigraphy/or computer assisted scintigraphy/or tomoscintigraphy/	19001
13	(scintiscan\$ or scintillogr\$ or scintigra\$ or scintillation).mp.	108196
14	(radionuclide adj2 (imag\$ or angiogra\$ or ventriculogra\$)).mp.	5568
15	12 or 13 or 14 [Scintigraphy]	111090
16	11 or 15 [CT or Scintigraphy]	1025987
17	5 and 16 [PH and imaging]	8567
18	chronic thromboembolic pulmonary hypertension/	2742
19	(CTEPH or (((thromboemboli\$ or thrombo-emboli\$) adj2 (pulmonary adj2 hypertens\$)) or disease\$ or chronic)).mp.	6863491
20	18 or 19 [CTEPH]	6863491
21	pulmonary veno-occlusive disease/	548
22	((lung or pulmonary) adj2 (venoocclusi\$ or veno-occlusi\$)).mp.	683
23	21 or 22	683
24	pulmonary capillary hemangiomatosis/	196
25	(pulmonary adj2 capillary adj2 h\$emangiomatosis).mp.	248
26	24 or 25 [PCH]	248
27	20 or 23 or 26 [CTEPH or PVOD or PCH]	6863522
28	17 and 27	6859
29	limit 28 to English language	6357
30	limit 29 to yr = "2008-Current"	5450
31	limit 30 to (conference abstract or editorial or letter)	1815
32	30 not 31	3635

Table E8. MEDLINE search strategy for question 3a

Question 3a: Can imaging determine the severity of pulmonary hypertension?		
Row	Search terms	Number citations
1	hypertension, pulmonary/or familial primary pulmonary hypertension/	31804
2	((pulmonary or lung) adj3 hypertensi\$).mp.	48785
3	(pulmonary adj2 (heart or vascular or arter\$ or cardiac) adj2 disease\$).mp.	9773
4	(corpulmonale or cor pulmonale).mp.	4020
5	1 or 2 or 3 or 4	55766
6	magnetic resonance imaging/or diffusion magnetic resonance imaging/or echo-planar imaging/or ¹⁹ F magnetic resonance imaging/or magnetic resonance angiography/or magnetic resonance imaging, cine/	396478

7	(MRI or MRIs or (magnet\$ adj2 (transfer or resonance) adj2 (tomogra\$ or imag\$ or angiogra\$)) or ((MR or NMR) adj imag\$)).mp.	528834
8	(echo adj2 (planar or spin) adj2 imag\$).mp.	8319
9	6 or 7 or 8	529782
10	tomography, x-ray computed/or computed tomography angiography/or four-dimensional computed tomography/	355357
11	((electrocardiogra\$ or ECG\$) adj2 (gated or synchroni\$)).mp.	2710
12	((computer\$ adj2 (assisted or diagnos\$)) or CT scan\$ or ((positron or compute\$ or emission) adj3 tomograph\$) or tomoscintigra\$ or PET scan\$ or (CT adj2 (scan\$ or angiogra\$ or dual-energy))).mp.	849613
13	11 or 12	850311
14	10 or 13 [CT]	850311
15	9 or 14	1202294
16	5 and 15	3517
17	limit 16 to English language	3046
18	limit 17 to yr = "2008-Current"	2210
19	limit 18 to (comment or editorial or letter)	97
20	18 not 19	2113

Table E9. EMBASE search strategy for question 3a

Question 3a: Can imaging determine the severity of pulmonary hypertension?		
Row	Search terms	Number citations
1	hypertension, pulmonary/or familial primary pulmonary hypertension/	40563
2	((pulmonary or lung) adj3 hypertensi\$).mp.	72621
3	(pulmonary adj2 (heart or vascular or arter\$ or cardiac) adj2 disease\$).mp.	6051
4	(corpulmonale or cor pulmonale).mp.	2721
5	1 or 2 or 3 or 4	76921
6	exp nuclear magnetic resonance imaging/	774826
7	(MRI or MRIs or (magnet\$ adj2 (transfer or resonance) adj2 (tomogra\$ or imag\$ or angiogra\$)) or ((MR or NMR) adj imag\$)).mp.	797608
8	(echo adj2 (planar or spin) adj2 imag\$).mp.	8269
9	6 or 7 or 8	827600
10	exp computer assisted tomography/	807433
11	((electrocardiogra\$ or ECG\$) adj2 (gated or synchroni\$)).mp.	3633
12	((computer\$ adj2 (assisted or diagnos\$)) or CT scan\$ or ((positron or compute\$ or emission) adj3 tomograph\$) or tomoscintigra\$ or PET scan\$ or (CT adj2 (scan\$ or angiogra\$ or dual-energy))).mp.	956339
13	11 or 12	957338
14	10 or 13 [CT]	960662
15	9 or 14	1549245
16	5 and 15	10802
17	limit 16 to English language	10167
18	limit 17 to yr = "2008-Current"	8908
19	limit 18 to (conference abstract or editorial or erratum or letter or note)	3593
20	18 not 19	5315
21	limit 20 to (adult < 18 to 64 years > or aged < 65+ years >)	3050

Table E10. MEDLINE search strategy for question 3b

Question 3b: Can imaging determine the complications of pulmonary hypertension?		
Row	Search terms	Number citations
1	hypertension, pulmonary/or familial primary pulmonary hypertension/	31804
2	((pulmonary or lung) adj3 hypertensi\$).mp.	48785

3	(pulmonary adj2 (heart or vascular or arter\$ or cardiac) adj2 disease\$).mp.	9773
4	(corpulmonale or cor pulmonale).mp.	4020
5	1 or 2 or 3 or 4	55766
6	magnetic resonance imaging/or diffusion magnetic resonance imaging/or echo-planar imaging/or ¹⁹ F magnetic resonance imaging/or magnetic resonance angiography/or magnetic resonance imaging, cine/	396478
7	(MRI or MRIs or (magnet\$ adj2 (transfer or resonance) adj2 (tomogra\$ or imag\$ or angiogra\$) or ((MR or NMR) adj imag\$)).mp.	528834
8	(echo adj2 (planar or spin) adj2 imag\$).mp.	8319
9	6 or 7 or 8	529782
10	tomography, x-ray computed/or computed tomography angiography/or four-dimensional computed tomography/	355357
11	((electrocardiogra\$ or ECG\$) adj2 (gated or synchroni\$)).mp.	2710
12	((computer\$ adj2 (assisted or diagnos\$) or CT scan\$ or ((positron or compute\$ or emission) adj3 tomograph\$) or tomoscintigra\$ or PET scan\$ or (CT adj2 (scan\$ or angiogra\$ or dual-energy))).mp.	849613
13	11 or 12	850311
14	10 or 13 [CT]	850311
15	radionuclide imaging/or radionuclide angiography/or exp radionuclide ventriculography/	91075
16	(scintiscan\$ or scintillogr\$ or scintigra\$ or scintillation).mp.	59891
17	(radionuclide adj2 (imag\$ or angiogra\$ or ventriculogra\$)).mp.	92222
18	positron emission tomography computed tomography/or single photon emission computed tomography computed tomography/	4543
19	15 or 16 or 17 or 18	129801
20	9 or 14 or 19	1300102
21	5 and 20	4207
22	limit 21 to English language	3493
23	limit 22 to yr = "2008-Current"	2259
24	limit 23 to (comment or editorial or letter)	99
25	22 not 24	2160

Table E11. EMBASE search strategy for question 3b

Question 3b: Can imaging determine the complications of pulmonary hypertension?		
Row	Search terms	Number citations
1	hypertension, pulmonary/or familial primary pulmonary hypertension/	40563
2	((pulmonary or lung) adj3 hypertensi\$).mp.	72621
3	(pulmonary adj2 (heart or vascular or arter\$ or cardiac) adj2 disease\$).mp.	6051
4	(corpulmonale or cor pulmonale).mp.	2721
5	1 or 2 or 3 or 4	76921
6	exp nuclear magnetic resonance imaging/	774826
7	(MRI or MRIs or (magnet\$ adj2 (transfer or resonance) adj2 (tomogra\$ or imag\$ or angiogra\$) or ((MR or NMR) adj imag\$)).mp.	797608
8	(echo adj2 (planar or spin) adj2 imag\$).mp.	8269
9	6 or 7 or 8	827600
10	exp computer assisted tomography/	807433
11	((electrocardiogra\$ or ECG\$) adj2 (gated or synchroni\$)).mp.	3633
12	((computer\$ adj2 (assisted or diagnos\$) or CT scan\$ or ((positron or compute\$ or emission) adj3 tomograph\$) or tomoscintigra\$ or PET scan\$ or (CT adj2 (scan\$ or angiogra\$ or dual-energy))).mp.	956339
13	11 or 12	957338
14	10 or 13 [CT]	960662
15	scintigraphy/or computer assisted scintigraphy/or tomoscintigraphy/	18941
16	(scintiscan\$ or scintillogr\$ or scintigra\$ or scintillation).mp.	107984
17	(radionuclide adj2 (imag\$ or angiogra\$ or ventriculogra\$)).mp.	5556
18	15 or 16 or 17	110869

19	9 or 14 or 18	1601521
20	5 and 19	11305
21	limit 20 to English language	10588
22	limit 21 to yr = "2008-Current"	9181
23	limit 22 to (conference abstract or editorial or letter or note)	3732
24	22 not 23	5449
25	limit 24 to (adult < 18 to 64 years > or aged < 65+ years >)	3128

Table E12. MEDLINE search strategy for question 4

Question 4: How should imaging be used to assess chronic thromboembolic pulmonary hypertension before treatment?		
Row	Search terms	Number citations
1	((lung\$ or bronch\$ or pulmonary) adj2 (angiogra\$ or arteriogra\$)).mp.	4840
2	magnetic resonance imaging/or diffusion magnetic resonance imaging/or echo-planar imaging/or ¹⁹ F magnetic resonance imaging/or magnetic resonance angiography/or magnetic resonance imaging, cine/	397232
3	(MRI or MRIs or (magnet\$ adj2 (transfer or resonance) adj2 (tomogra\$ or imag\$ or angiogra\$)) or ((MR or NMR) adj imag\$)).mp.	529750
4	(echo adj2 (planar or spin) adj2 imag\$).mp.	8328
5	2 or 3 or 4	530697
6	tomography, x-ray computed/or computed tomography angiography/or four-dimensional computed tomography/	356065
7	((electrocardiogra\$ or ECG\$) adj2 (gated or synchroni\$)).mp.	2711
8	((computer\$ adj2 (assisted or diagnos\$)) or CT scan\$ or ((positron or compute\$ or emission) adj3 tomograph\$) or tomoscintigra\$ or PET scan\$ or (CT adj2 (scan\$ or angiogra\$ or dual-energy\$))).mp.	850915
9	7 or 8	851613
10	6 or 9 [CT]	851613
11	(CTEPH or ((thromboemboli\$ or thrombo-emboli\$) adj2 (pulmonary adj2 hypertens\$)) or ((thromboemboli\$ or thrombo-emboli\$) adj2 (disease\$ or chronic\$))).mp.	7370
12	1 or 5 or 10	1206435
13	11 and 12	987
14	limit 13 to yr = "2008-Current"	554
15	limit 14 to (comment or editorial or letter)	11
16	14 not 15	543

Table E13. EMBASE search strategy for question 4

Question 4: How should imaging be used to assess chronic thromboembolic pulmonary hypertension before treatment?		
Row	Search terms	Number citations
1	lung angiography/	6438
2	((lung\$ or bronch\$ or pulmonary) adj2 (angiogra\$ or arteriogra\$)).mp.	8649
3	1 or 2	8649
4	exp nuclear magnetic resonance imaging/	774826
5	(MRI or MRIs or (magnet\$ adj2 (transfer or resonance) adj2 (tomogra\$ or imag\$ or angiogra\$)) or ((MR or NMR) adj imag\$)).mp.	797608
6	(echo adj2 (planar or spin) adj2 imag\$).mp.	8269
7	4 or 5 or 6	827600
8	exp computer assisted tomography/[Embase]	807433
9	((electrocardiogra\$ or ECG\$) adj2 (gated or synchroni\$)).mp.	3633
10	((computer\$ adj2 (assisted or diagnos\$)) or CT scan\$ or ((positron or compute\$ or emission) adj3 tomograph\$) or tomoscintigra\$ or PET scan\$ or (CT adj2 (scan\$ or angiogra\$ or dual-energy\$))).mp.	956339
11	9 or 10	957338
12	8 or 11 [CT]	960662
13	chronic thromboembolic pulmonary hypertension/	2722
14	(CTEPH or ((thromboemboli\$ or thrombo-emboli\$) adj2 (pulmonary adj2 hypertens\$)) or ((thromboemboli\$ or thrombo-emboli\$) adj2 (disease\$ or chronic\$))).mp.	9619

15	13 or 14	9619
16	3 or 7 or 12	1551236
17	15 and 16	2106
18	limit 17 to English language	1913
19	limit 18 to yr = "2008-Current"	1554
20	limit 19 to (conference abstract or editorial or letter or note)	707
21	19 not 20	847

Table E14. MEDLINE search strategy for question 5

Question 5: Should imaging be performed after treatment of chronic thromboembolic pulmonary hypertension?		
Row	Search terms	Number citations
1	(CTEPH or ((thromboemboli\$ or thrombo-emboli\$) adj2 (pulmonary adj2 hypertens\$)) or ((thromboemboli\$ or thrombo-emboli\$) adj2 (disease\$ or chronic))).mp.	7362
2	exp Angioplasty, Balloon/	51258
3	((balloon or transluminal or percutaneous) adj2 (arter\$ dilat\$ or angioplasty)).mp.	58103
4	2 or 3	58103
5	exp Endarterectomy/	14670
6	surgery/or (surgery or surgical\$ or surgeries).tw.	1644262
7	(end arteriecto\$ or thromboendarterecto\$ or endarterecto\$ or endarteriecto\$).mp.	19283
8	5 or 6 or 7	1655279
9	4 or 8	1701692
10	1 and 9	2039
11	limit 10 to English language	1653
12	limit 11 to yr = "2008-Current"	1013
13	limit 12 to (comment or editorial or letter)	67
14	12 not 13	946

Table E15. EMBASE search strategy for question 5

Question 5: Should imaging be performed after treatment of chronic thromboembolic pulmonary hypertension?		
Row	Search terms	Number citations
1	chronic thromboembolic pulmonary hypertension/	2722
2	(CTEPH or ((thromboemboli\$ or thrombo-emboli\$) adj2 (pulmonary adj2 hypertens\$)) or ((thromboemboli\$ or thrombo-emboli\$) adj2 (disease\$ or chronic))).mp.	9619
3	percutaneous transluminal angioplasty/	22703
4	((balloon or transluminal or percutaneous) adj2 (arter\$ dilat\$ or angioplasty)).mp.	47433
5	3 or 4	47433
6	exp Endarterectomy/	19598
7	surgery/or (surgery or surgical\$ or surgeries).tw.	1764330
8	(end arteriecto\$ or thromboendarterecto\$ or endarterecto\$ or endarteriecto\$).mp.	21407
9	6 or 7 or 8	1776492
10	5 or 9	1813416
11	1 or 2	9619
12	10 and 11	3218
13	limit 12 to English language	2801
14	limit 13 to yr = "2008-Current"	2277
15	limit 14 to (conference abstract or editorial or letter or note)	1177

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141. Melzig C, Wörz S, Egenlauf B, et al. Combined automated 3D volumetry by pulmonary CT angiography and echocardiography for detection of pulmonary hypertension. *Eur Radiol* 2019;29(11):6059–6068.
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