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Original Article

Endovascular Treatment of a Haemodynamically Unstable Massive Pulmonary Embolism using Fibrinolysis and Fragmentation. Experience with 111 Patients in a Single Centre. Why don't we follow ACCP Recommendations?

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ABSTRACT

Introduction: Fibrinolysis is recommended in several consensus documents for the treatment of hemodynamically-unstable massive pulmonary embolism (MPE).
Material and methods: A total of 111 patients were treated in a single center from January 2001 to December 2009. Fifty-five were male and 56 female, all diagnosed with hemodynamically-unstable MPE (systolic arterial pressure > 90 mmHg) with at least two of the following criteria: Miller index > 0, ventricular dysfunction, and need for vasoactive drugs. Local fibrinolysis with urokinase was performed in all cases as was fragmentation with a pig-tail catheter in most. An inferior vena cava (IVC) filter was implanted in 94 patients as a prophylactic measure.
Results: Technical success was 100%. The Miller index improved from 0.7 ± 0.12, pre-treatment, to 0.09 ± 0.16. Mean pulmonary arterial pressure went from 39.93 ± 7.0 mmHg to 20.47 ± 3.3 mmHg at the 30-90 day follow-up. Ninety-four patients had IVC filters implanted, 79% of which were withdrawn satisfactorily. Seven patients died: 3 due to neoplasia; 3 due to right cardiac failure at 1, 7 and 30 days; and another died of a brain hemorrhage within the first 24 hours. There were complications in 12.6% of the cases, of which 4.5% were major.
Conclusion: Local fibrinolysis with fragmentation achieves rapid normalization of the pulmonary pressure and is a safe and effective method for the treatment of hemodynamically-unstable MPE.

Tratamiento endovascular mediante fibrinólisis y fragmentación del embolismo pulmonar masivo con inestabilidad hemodinámica. Experiencia de un solo centro en 111 pacientes. ¿Por qué no seguimos las recomendaciones de la ACCP?

RESUMEN

Introducción: La fibrinolisis está recomendada en los diferentes consensos para el tratamiento del embolismo pulmonar masivo hemodinámicamente inestable (EPmHI).
Material y métodos: En un solo centro desde enero de 2001 hasta diciembre de 2009 se han tratado 111 pacientes (55 hombres y 56 mujeres) diagnosticados de EPmHI (presión arterial sistólica < 90 mmHg) con al menos dos de los siguientes criterios: índice de Miller > 0, disfunción ventricular y necesidad de drogas vasoactivas. En todos los casos se realizó fibrinolisis local con uroquinasa y en la mayoría fragmentación

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con catéter *pig-tail*. Se implantó un filtro de vena cava inferior (VCI) en 94 pacientes como medida profiláctica.

Resultados: El éxito técnico fue del 100%. El índice de Miller mejoró de 0,7 ± 0,12 pre-tratamiento a 0,09 ± 0,16. La presión arterial pulmonar media pasó de 39,93 ± 7,0 mmHg a 20,47 ± 3,3 mmHg en el control de 30-90 días. A 94 pacientes se les implantó un filtro de VCI que se pudo retirar en el 79% de forma satisfactoria. Siete pacientes fallecieron: 3 en el curso de su neoplasia, 3 por insuficiencia cardíaca derecha a 1, 7 y 30 días y otro falleció de hemorragia cerebral en las primeras 24 horas. Hubo complicaciones en el 12,6% de los casos, de las que 4,5% fue mayor.

Conclusión: La fibrinolisis local con fragmentación consigue la normalización rápida de la presión pulmonar y constituye un método seguro y eficaz para el tratamiento del EPmHI.

Introduction

The 8th Conference of the American College of Chest Physicians (ACCP) has once again recommended fibrinolysis in grade 1B (2B in the 7th) for patients with massive pulmonary emboli and compromised hemodynamics, while with the same grade of evidence it recommends systemic over local delivery.[1] This recommendation is not surprising, as it repeats that of previous consensus[2] and at the moment of its publication there were no available innovations. ¿What does the ACCP base this guideline on regarding fibrinolysis in pulmonary embolism in all its guidelines? The knowledge on which it is based arises from the article by Vertstraete et al. published in *Circulation* in 1988.[3] Said study was a multi-center study including 8 hospitals, where 34 patients diagnosed with massive pulmonary embolism were treated with rtPA: 19 administered *in situ* in the pulmonary artery and 15 systemically. The results declared that pulmonary artery treatment *in situ* did not offer any benefits over systemic venous delivery. One of the most important limitations of the study by Verstraete was the low number of patients and the recruitment of patients per center, which averaged 4 per center. The administration of fibrinolytics in the trunk of the pulmonary artery without going through the thrombus and its non-fragmentation constitute other important limitations. The guidelines for the diagnosis and management of pulmonary embolism by the European Society of Cardiology recommend fibrinolysis for patients at high vital risk, without specifying local or peripheral delivery.[4] Currently, intrapulmonary access is not conceived simply to infuse fibrinolytics in the pulmonary trunk. Local fibrinolysis near the thrombus, or even better intra-thrombus, and fragmentation with a catheter or with other devices, is the recommendation in these cases.[5,6] In the review and meta-analysis about massive embolism treatment by Kuo el al.,[7] catheter techniques are proposed as the first line of treatment in massive pulmonary embolism in experienced centers with adequate means. We present our experience with 111 patients with hemodynamically-unstable massive pulmonary embolism (MPE) treated with local fibrinolysis and fragmentation of the thrombus.

Material and Methods

Patients

From January 2001 to December 2009, 111 patients diagnosed with hemodynamically-unstable MPE were treated with fibrinolysis and mechanical fragmentation with a catheter. All of the subjects, 55 males and 56 females, came from one single center, with a mean age of 60 ± 15 years (age range 27-79). The study included patients between the ages of 18 and 80, diagnosed angiographically or by angio-CT with hemodynamically-unstable MPE (systolic blood pressure < 90 mmHg) and at least two of the following criteria: a) Miller index > 0.5; b) ventricular dysfunction on ultrasound established by the increase in RV volume, RV hypokinesia and tricuspid systolic velocity > 2.6 m/s on Doppler; and c) the need to administer more than 5 micrograms/Kg/minute of inotropic drugs to maintain blood pressure. In all cases, informed consent was obtained and the study was approved of by the Ethics Committee of the Autonomous Community of Aragón. For the treatment with fibrinolytics, the following were considered contraindications: pregnancy, major surgery within the previous 72 hours, craneoencephalic trauma in the last month, cerebrovascular accident in the last six months, uncontrolled blood pressure (diastolic pressure > 120 mmHg at the moment of treatment), active hemorrhage or serious coagulation alteration and serious renal or hepatic disease.

Risk factors for venous thromboembolic disease and comorbidities were studied, as were clinical and analytical data. The ASA index and the Wells scale were retrospectively established for the patients included in the study.

Morphological and Hemodynamic Study

The diagnosis for pulmonary embolism was generally based on the radiological criteria of repletion defects in the main pulmonary, lobar or segmental artery on CT. For all patients, diagnostic suspicion of massive pulmonary embolism was confirmed angiographically. Diagnostic criteria were: intra-arterial filling defects and perfusion defects. Angiography was performed through the right jugular using a 6 French curved pigtail catheter (55°) and pressures were taken in the main pulmonary trunk and in each of the two branches. Right auricle and inferior vena cava pressures were also taken. Three injections were given of 20 cc of non-ionic contrast for anteroposterior and right and left anterior oblique projections. With the morphological data, the Miller index was established. This is a quantitative angiographic parameter used to measure the degree of lung affection (intravascular emboli and perfusion alteration), which allow us to later control the evolution of the patients. It is based on the data obtained angiographically and evaluates the degree of vascular obstruction (right lung = 9 points and left lung = 7 points) and the perfusion of each lung (9 points each). Perfusion is evaluated in three different areas of each lung, giving to each a score of 1 (moderately reduced flow) and 0 (normality). The result obtained from adding all the parameters of both lungs is divided into 34, giving the Miller index score.[8] Therefore the closer the index is to one, the poorer the situation of the patient. With the clinical, morphological and hemodynamic data, and according to the previously-established criteria, inclusion was decided (fig. 1).

Mechanical Fragmentation and Thrombolysis

Patients with inclusion criteria were administered fibrinolytics *in situ* of between 200,000-500,000 IU of urokinase. Afterwards, 94 patients (84.6%) underwent fragmentation of the most extensive lesions using rotating movements with the angiography catheter (6 F curved pigtail catheter, 100 cm; Cook Europe ApS, Bjaeverskov, Denmark). In only 12 patients, in addition to the pig-tail catheter, a 2 cm-long, 8-12 mm diameter angioplasty balloon was used to
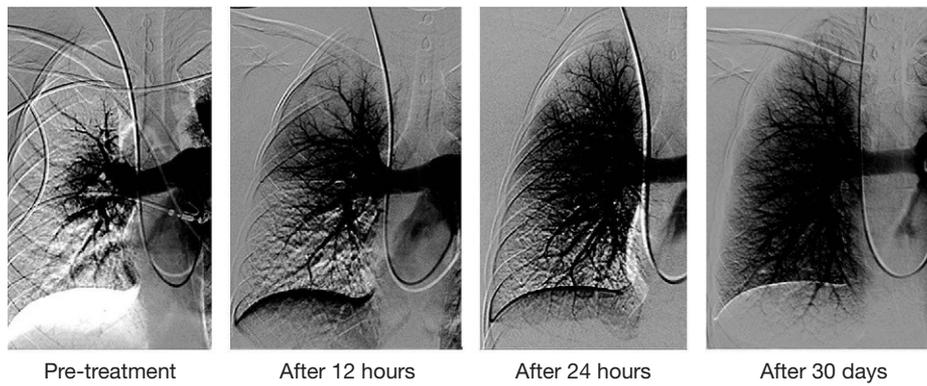
Figure 1. Fifty-eight-year-old male patient with massive pulmonary thromboembolism, shock with a Miller index of 0.7 and mean pulmonary artery pressure (PAP-m) of 42 mm Hg. Examination 12 hours after fibrinolytic treatment (100,000 IU of UK/hour) showed improvement of the Miller index and PAP-m 38 mm Hg; 24 hours afterwards, PAP was 27 mm Hg. The 30-day follow-up showed PAP-m 18 mm Hg, and the Miller index was 0.

fragment the thrombus (Cook Medical, Bjaeverskov, Denmark). Later, through the catheter located in the most obstructed arterial segment, an infusion of urokinase (Urokinase Vedic, Vedim Pharma, Barcelona, Spain) was administered at 100,000 IU/h for 12 hours. Patients were controlled for bleeding point, blood pressure and coagulation study, as well as a new angiographic study with artery pressures taken. With these data, the decision was made of whether to finalize treatment or continue with the same measures for another 12 hours, at which time the intrapulmonary catheter and thrombolysis were withdrawn to change to anticoagulation with sodium heparin.

During thrombolysis, all patients received treatment with heparin sodium at a dosage adjusted to ATTP ratio values of 2-2.3 in order to avoid the formation or progression of new fibrin deposits on the already-formed thrombus and on the angiography catheter (fig. 2).

Implantation of Vena Cava Filters

With the aim of impeding a new embolism in patients with suspected deep-vein thrombosis of the lower extremities, pelvis or vena cava, an optional filter was implanted with the intention of removing it after 1-3 months. The vena cava filters used were from Günther Tulip (Cook Europe ApS, Bjaeverskov, Denmark) and Celect (Cook Europe ApS, Bjaeverskov, Denmark). To implant both types of filter, the right jugular was used. In order to do so, the 6 F introducer was substituted for the 8 F introducer that comes with the filter

introduction set (Cook Europe ApS, Bjaeverskov, Denmark). With fluoroscopic control, cavography was performed to rule out thrombosis in said vein and to locate the height of the renal veins. Above this position, the filter was released extremely carefully to avoid angulations that could later affect extraction.

Retrieval of Vena Cava Filters

In order to retrieve the filters, 30 days later in the case of the Günther Tulip filter and 90 days later for the Celect filter, vena cava angio-CT was done to evaluate the permeability of the vena cava and to study the position of the retrieval hook with regards to the vein wall. In all cases, the right jugular vein was used and for the extraction of the filter the specific extractor for the filter was used (Cook Europe ApS, Bjaeverskov, Denmark). During this exploration and in all cases, pulmonary angiography and hemodynamic study were carried out and pressures taken (fig. 3).

Clinical, Hemodynamic and Morphological Follow-up

Follow-up and clinical evaluation was 1, 3, 6 and 12 months afterwards. In the cases of patients bearing filters, angiographic and hemodynamic studies were completed at 30 or 90 days. In patients with high pulmonary pressures in the post-procedure examination and a high Miller index, pulmonary gammagraphy and Doppler
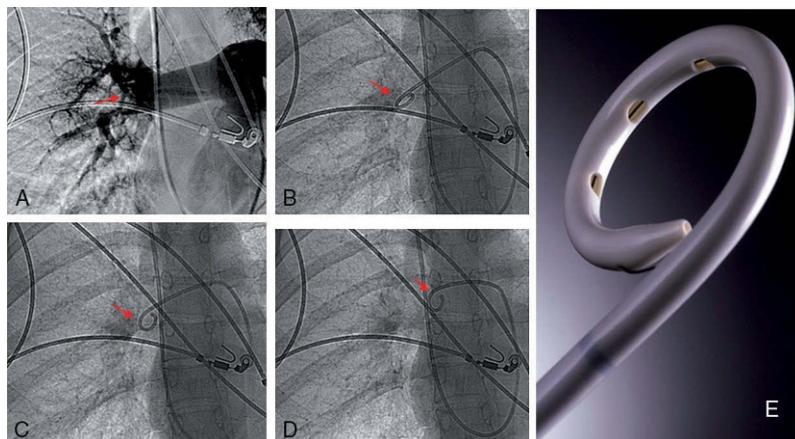

Figure 2. Standard technique for fragmentation of thrombus. Using in-an-out rotating movements (A-D) with the pig-tail catheter (E), the thrombus situated in the lobar and segmental vessels are fragmented.
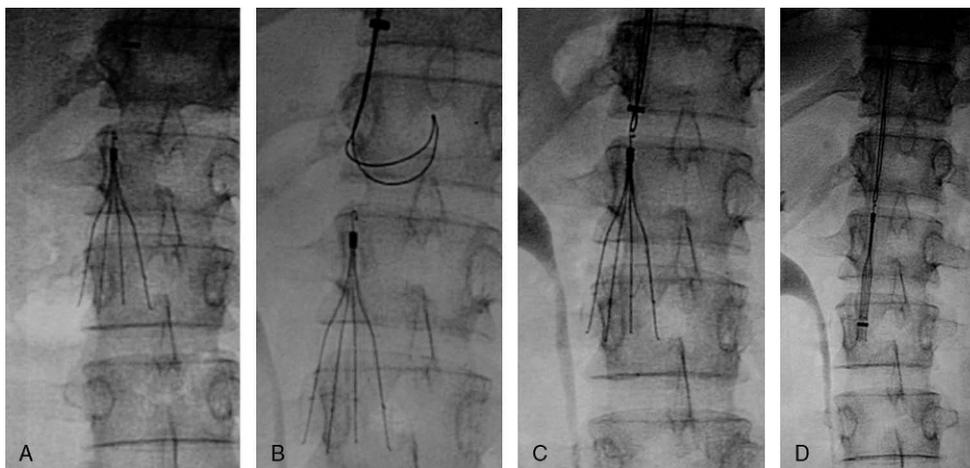
Figure 3. Extraction of Günther Tulip vena cava filter. A) Filter in IVC. B) Retrieval loop. C) Grasping of filter. D) Introduction of the filter into retrieval sheath.

ultrasound were done at 3 and 6 months. Patients received treatment with dicumarin for 6 months.

Results

Patients

All patients were diagnosed with Hemodynamically-unstable MPE with a Miller index of 0.71 ± 0.12 (range 0.40-0.90) and mean systolic blood pressure of 71.68 ± 10.85 (range: 40-90). On ultrasound, 82% of the patients presented ventricular dysfunction with septal deviation.

In 15 patients (13.5%) of our series, there were no clear risk factors for venous thromboembolic disease. The remainder (86.4%) had clear risk factors (table 1), the most frequent being recent prior surgery (43.2%).

Ninety-one patients (81.9%) were diagnosed with deep vein thrombosis (DVT) by Doppler ultrasound or CT. Of these, 32 patients (35.1%) had been diagnosed prior to the episode of hemodynamically-unstable MPE and the remainder was diagnosed during or after MPE diagnosis. In 20 patients, lower limb DVT could not be demonstrated by imaging, nor did patients demonstrate symptoms for thrombosis in any other location.

All patients presented important signs and symptoms indicative of pulmonary embolism, the most frequent initial symptom being dyspnea (70.2%). Twenty-six patients debuted with syncope (23.4%). With the clinical data of our series, the predictive value of the Wells score was 6.9 ± 1.9 (range: 4-10). Mean O_2 saturation on pulse oximetry in the radiology intervention room was 67.3 ± 8.9% (range: 39-82%). The shock index was 0.89 ± 0.6. Eighteen patients presented

clinical comorbidities (8 COPD, 4 diabetes, 4 coronary disease and 2 cerebrovascular accidents in their histories). At the time of hospitalization, D-dimer was studied with a mean value of 2,015.73 ng/dl (range: 230-11,500 ng/dl), while troponin I had a mean value of 0.06 ± 0.05 ng/dl (range: 0.01-0.45 ng/dl). Retrospectively, we analyzed the situation of the patient prior to pulmonary embolism in accordance with the ASA classification: 73 (65.7%) were in ASA I; 26 (23.4%) in ASA II; and 12 (10.8%) ASA III (table 2).

At this time, 7 of the patients have died (6.3%). Three cases were related to neoplasia diagnosed prior to the MPE event, dying at 3 months, 1 year and 2 years afterwards. Another 3 patients died within the first 30 days related to their thromboembolic disease, happening in the first 24 hours, 1 week and 1 month. The cause of death in the three cases was right cardiac insufficiency, with no signs of recurrent embolism. Another patient demised as a result of massive intracerebral hemorrhage 48 hours after establishing treatment with fibrinolytics. The three patients who died from cardiac failure, aged 65, 73 and 79, had debuted with shock and had high levels of troponin t (0.17, 0.20 and 0.21 ng/ml) while suffering from important comorbidities (2 COPD, 1 previous heart disease). However, significant differences could not be demonstrated in the evolution of pulmonary arterial pressure (PAP) between those patients who had begun with syncope and those who had not, either in the post-fibrinolysis results or in the follow-up after 41 days (p > 0.38) (fig. 4).

Table 1
Frequency of the main risk factors and their percentage

Risk factor	n	%
Previous surgery	47	43.2
Abdominal and gynecological surgery	32	
Orthopedic surgery	15	
Immobilization (bed rest)	20	18.0
History of LL trauma	11	9.9
Cancer	8	7.2
Obesity and varicose veins	3	2.7
Other (anovulation, etc.)	7	6.3
Unknown	15	13.5

LL: lower-limb.

Table 2
Main demographic data and vital signs of the patients at hospitalization

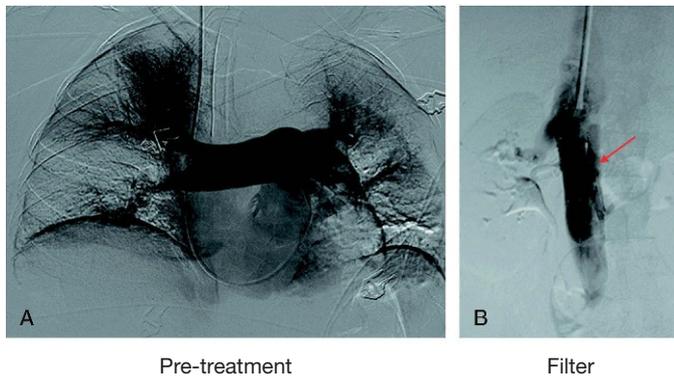|	Mean ± SD	
Age	60 ± 15	
PaO_2 pulse oximetry	67.3 ± 8.9	
Blood pressure		
Systolic	62.06 ± 15	
Mean	39.93 ± 7	
	n (N = 111)	%
Sex		50.45
Males	55	49.54
Females	56	49.54
Initial symptom: syncope	41	36.9
Need for inotropic drugs	80	72.07
Need for mechanical ventilation	56	50.45

SD: standard deviation.

Figure 4. Sixty-five-year-old patient in shock, intubated, PO_2 64 mm Hg. Miller index 0.8 and PAP-m 56 mm Hg. On the right, implantation of the GT filter under the renal veins. The cause of death was right cardiac insufficiency in the first 24 hours.

Angiographic and Hemodynamic Findings

The procedure was able to be performed in all patients (100% technical success). Mean pre-treatment PAP was 39.2 ± 6.9 mmHg (range 28-69 mmHg) with Miller index of 0.7 ± 0.1 (range 0.5-0.8). Fragmentation with the initial dosage of fibrinolytics administered in bolus of 250,000 to 500,000 of urokinase did not significantly reduce PAP (mean PAP 39.24 mmHg) ($p > 0.05$). Nevertheless, the reduction in mean PAP was significant after treatment with fibrinolytics ($p < 0.05$). As for the initial pressure, decreases were verified in systolic pressure and mean pressure of 17.81 ± 3.7 mmHg and 14.59 ± 2.5 mmHg, respectively. This improvement was registered at the examination to retire fibrinolysis 2.8 ± 1.2 days after the start of treatment. The Miller index also showed improvement (mean 2.37 ± 0.11) with a significant decrease of 0.4 ($p < 0.05$).

Ninety-four patients underwent angiographic study and their pressures were taken 41.5 days after hemodynamically-unstable MPE (range: 29-92 days). Miller index was 0.09 ± 0.16 (range 0-0.5), with a mean PAP of 20.47 ± 3.3 mmHg (range 12-32 mmHg) which meant an overall reduction of 18.73 mmHg (fig. 1 and table 3). Angiographically, new signs of pulmonary embolism relapse were not observed.

Taking 25 mmHg as a normal mean PAP value, 47.3% of the patients had higher mean PAP. Meanwhile, at the 30-90 day follow-up, only 6 patients (6.5%) had pressure higher than 25 mmHg. In the 6 cases, mean PAP was 29 mmHg (range: 25-32) ([Figure 5], [Figure 6] and [Figure 7].)

Dosage of Fibrinolytics and Anticoagulants

In all cases, urokinase was administered as a fibrinolytic. Mean dosage was 2.82 ± 0.89 million IU of urokinase (range 1-4.5 million IU) administered at 100,000 IU/hour. Mean fibrinolysis time was 21.69 ± 11.92 hours (range 2-72 hours). The dosage of heparin sodium by infusion pump was administered according to the hematology lab guidelines, adjusting the ATTP ratio to 2.25 ± 0.37 (range: 0.70-2.5).
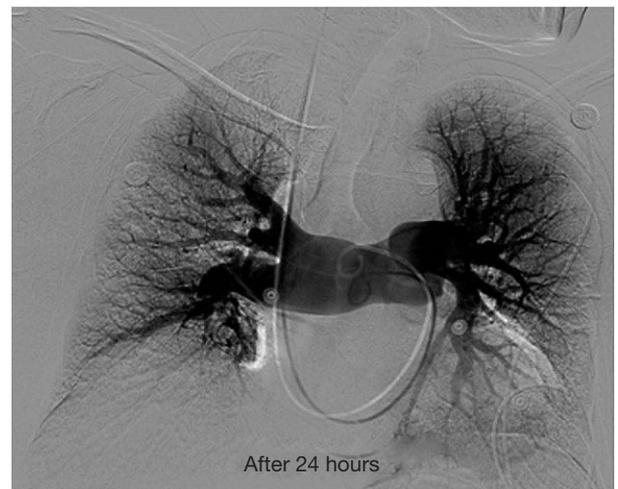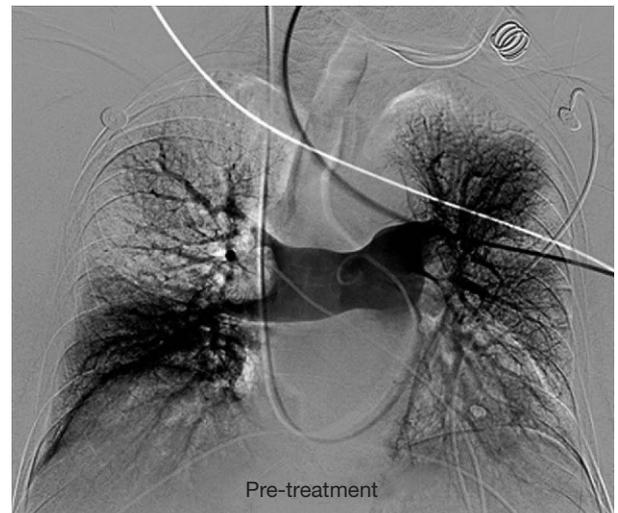

Figure 5. Fifty-eight-year-old patient with massive PTE and shock. Pre-treatment: PAP-m 48 mm Hg; Miller index 0.7. Post-treatment: PAP-m 32 mm Hg; Miller index 0.

Complications

There were complications derived from the angiographic technique and/or fibrinolysis in 14 patients (12.6%), 4 of which were major and 10 were minor (table 4).

Implantation and Retrieval of Filters

In the 98 filters implanted, no significant complications due to the procedures were observed. The filters were implanted under the renal veins in 73.4% of the cases, while in 24.4% the implantation was juxtarenal and in two cases (2.0%) above the renal veins. Seventeen filters (17.3%) presented slight inclination (< 20%) in the immediate post-implantation follow-up. With fluoroscopic control and before

Table 3

Comparison between mean arterial pressure values and the Miller index pre- and post-treatment

Comparison	PAPm		Sig.	Miller index		Sig.
Pre-treatment/Post-fragmentation	39.93 ± 7	39.46 ± 6.39	NS	0.7 ± 0.12		
Pre-treatment/post-fibrinolysis		24.56 ± 5.21	p < 0.05		0.26 ± 0.12	p < 0.05
Pre-treatment/30-90 day follow-up		20.47 ± 3.3	p < 0.05		0.09 ± 0.16	p < 0.05

Data expressed as mean ± standard deviation. NS: not significant; PAPm: mean pulmonary arterial pressure; Sig.: significance.
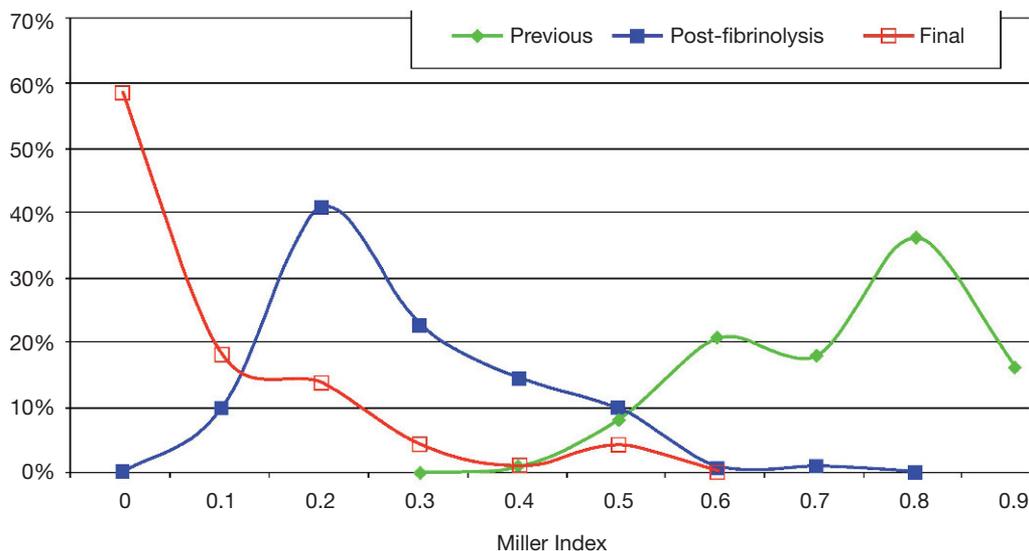
Figure 6. Evolution of the Miller index pre-treatment, post-treatment and at the 30-90 day follow-up.
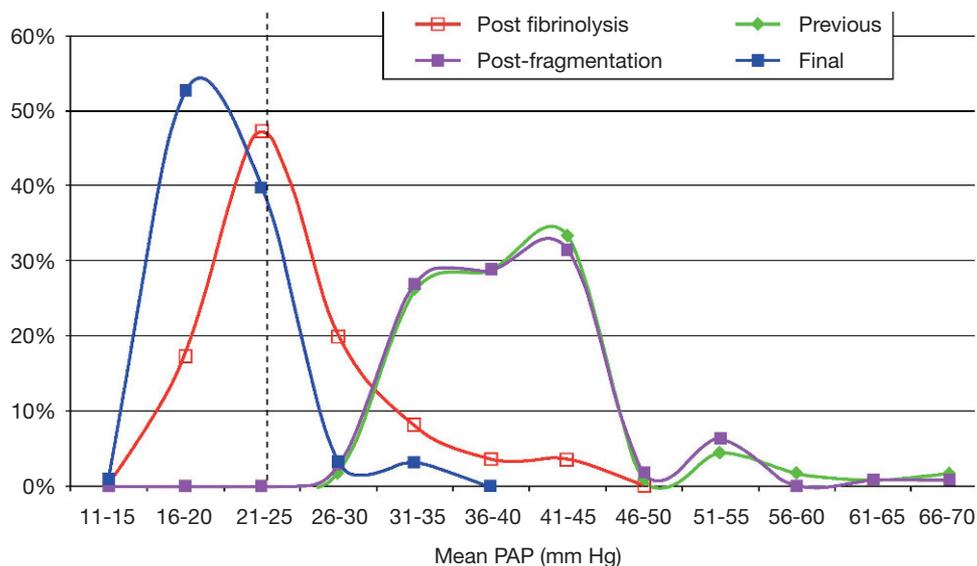

Figure 7. Evolution of mean pulmonary arterial pressure. Pre-fragmentation, post-fragmentation, post-fibrinolysis and final at 30-80 days. The discontinuous vertical line shows the normal value of mean pulmonary arterial pressure. PAP: pulmonary arterial pressure.

cavography, attempts were made at retrieving the filters in 94 (95.9%) patients out of 98 bearers, achieving retrieval in 78 (82.9%). In 16 patients (17.2%), retrieval was attempted but was not achieved due to different causes (in 14 patients the filter was inclined and the hook was enclosed in the wall, and in 2 patients there was important vena cava thrombosis). On 34 (45.3%) of the filters extracted, we observed, both on CT as well as on cavography, the presence of small thrombi trapped in the filter; these were aspirated with the introducer

Table 4
Complications and their evolution

Complications	n	%	Evolution
Major	4	4.5	
Intracerebral hematoma	1		Patient died in the first 24 hours
Hematoma, gluteus	1		Required transfusion and percutaneous drainage
Digestive hemorrhage	1		Transfusion of 2 units of blood
DVT jugular vein	1		Partial re-permeabilization 3 months
Minor	10	11.7	
Hematoma neck	8		Favorable evolution
Mild hematuria	1		Self-limited with no measures taken
Extrasystolia	1		Self-correction with no measures taken
Total	14	12.6	

DVT: deep vein thrombosis.

catheter. Protected fibrinolysis was not done, and there were no embolic complications during the procedure.

Clinical Follow-up

During the long-term follow-up (12 months), we found no signs of pulmonary embolism relapse or chronic pulmonary arterial hypertension. Patients with mean PAP > 25 mmHg were studied with Doppler ultrasound and gammagraphy. None showed significant changes. From a clinical standpoint, the patients remained asymptomatic.

Study Limitations

Ours is a retrospective study, and it would be more valuable if we had compared the results with a series of patients with similar characteristics and treatment with systemic fibrinolytics. Other limitations of this study, which are equally important, are that the cohort is made up of selected patients, and that our group is especially dedicated to, and has experience in, the techniques used.

Discussion

Massive pulmonary embolism is a serious pathology that presents high mortality due to acute right ventricular failure and cardiogenic shock.[9] The three-month mortality rate of patients with hemodynamically-unstable MPE and arterial pressure < 90 mmHg is 50%, above all in the initial days after MPE. It is therefore essential to quickly start treatment with anticoagulation and fibrinolysis.[10] As we have mentioned, the eighth edition of the ACCP published in 2008,[1] as in earlier editions,[11] relegates fibrinolytic treatment to patients either with hemodynamically-unstable MPE or in danger of cardiogenic shock (grade 1B). It also recommends the use of fibrinolytics in selected high-risk patients without hypotension, with MPE and low risk for bleeding (grade 2B).[1] For the remaining clinical situations, the recommendation is anticoagulation. If it is not possible or contraindicated, it recommends resorting to vena cava filters. The use of fibrinolytics in submassive PE is controversial.[12] Perlroth and Zamanian,[13,14] in their analysis of effectiveness and cost-effectiveness comparing fibrinolysis versus anticoagulation, have concluded that there are no available data to justify their use except in very selected patient groups with ventricular dysfunction and high risk for death. On the other hand, Konstantinides et al.,[15] in a randomized study of 256 patients with submassive PE, concluded that the association of fibrinolytics and heparin can improve clinical results and can prevent clinical deterioration. In our series, all patients with MPE (Miller index > 0.7) were hemodynamically unstable with a mean systolic PAP of 62.7 mmHg, which in 92.1% required maintenance with vasoactive drugs. Cardiac Doppler ultrasound also revealed ventricular dysfunction and/or septal deviation in 82%.

Despite the ACCP[1] recommendation (grade 1B) for the systemic administration of fibrinolytics in regimes of short infusions, our group used the pulmonary intra-arterial pathway to infuse the drug in several hours, based on our previous experience.[16,17]

The study on which the ACCP has based its recommendations regarding administration and infusion regime is by Verstraete et al.,[3] published in *Circulation* in 1988. The authors of said multi-center study compared, in 34 patients, the use of the systemic infusion of 50 mg of rtPA with the same dosage in pulmonary intra-arterial infusion, concluding that there were no significant differences between the two means of administration. In this study, however, the technical differences should be emphasized: 1) what strikes us most is that 8 centers were not able to recruit more than 34 patients (19 intra-arterial and 15 intravenous); 2) in the intra-arterial infusion, the catheter was in the main pulmonary artery and not in contact with the thrombus; and 3) they performed no type of fragmentation. Schmitz-Rode et al.[18]

have demonstrated in an *in vitro* study how the perfusion of a fibrinolytic through a catheter in the proximity of a thrombus is no more advantageous than systemic perfusion, while intra-thrombus perfusion produces adequate effects for fragmentation. In 1994, Tapson et al.[19] demonstrated in an animal model that local thrombolysis produced more efficient and faster lysis of the thrombus as it improved the exposure of the drug to its surface. Fava et al.[20] treated 17 patients with MPE by pharmacologically-associated thrombolysis with mechanical fragmentation, obtaining an improvement in the first hours of 88%. These authors establish that the main therapeutic objective in MEP should be the restoration of the pulmonary circulation and affirm that fragmentation and the use of fibrinolytics do so quickly and effectively in an important percentage of patients. The ACCP[1] advises against fragmentation (grade C) except in special cases, and then performed by expert groups. Even Nakazawa et al.[21] admit that fragmentation, when distal embolization is produced, increases pulmonary pressure. These data do not agree with the observations of different authors that extol fragmentation prior to fibrinolysis and have not observed increased pressure[22] and.[23] In our series, fragmentation lowered mean pulmonary arterial pressure, although this decrease was not significant (previous PAPm 39.97 ± 6.9 mmHg vs. 39.46 ± 6.3 mmHg post-fragmentation (p > 1,530). These data have been corroborated by other authors.[18,20] Greenberg et al.,[24] in their study in an *in vitro* model comparing fragmentation vs. fibrinolysis, concluded that fragmentation stabilizes the flow more quickly and produces small thrombi that are reduced by the fibrinolytic agents.

These satisfactory results were also observed in our series published in 2002,[16] where 59 patients were treated with thrombolysis and fragmentation with catheter, reaching a clinical improvement of 94% and a decrease in the mean pulmonary arterial pressure of > 20 mmHg. We suggest that an important benefit of fragmentation of the thrombus is that it produces greater surface area for urokinase contact and action.

As for prophylaxis with the inferior vena cava filter in hemodynamically-unstable MPE, the ACCP is against its routine use (grade 1A), reserving it exclusively for those cases in which anticoagulation is not possible (grade 1C). In the document, no reference is made to the use of retrievable filters and this data, in our opinion, is substantial. We hypothesize that in a serious situation with pulmonary arterial hypertension and right cardiac failure, another thrombus in the pulmonary vascular bed could be determinant, and a filter that can be removed simply and with few complications could avoid it. In a series of our own with 32 patients with PE and optional vena cava filter, retrieval entailed no complications in 31 (98%) one month after implantation.[25] Many other authors have used inferior vena cava inferior filters in MEP with similar aims and good results.[9,26-28] Nevertheless, the high incidence of DVT in our series should be noted, which reached 81.9% of all patients with hemodynamically-unstable MPE. Other authors,[29] in a review of 707 patients diagnosed with PE, recently found that 51.2% had concomitant DVT. In this patient group they found a higher incidence of death, and therefore concluded that concomitant DVT with PE would be a predicting factor for death in the first three months. The implantation of an IVC filter could prevent re-embolization and improve the mortality rate in this patient group.

In short, we admit that, although our results are good in the treatment of hemodynamically-unstable MPE, they completely deviate away from the doctrine and recommendations dictated by the ACCP. We accept the indication of thrombolysis in MPE, but we do not coincide with the recommendations of either the pathway or administration regime, nor in the use of vena cava filters.

Just like us, many others must have felt unorthodox without the support of a multicenter study or meta-analysis to endorse our work.[6,20-22,30]

In 2009, Kuo et al.,[7] from the Stanford University Medical Center (USA), published a meta-analysis including 35 studies on 594 patients

with MPE. Said study analyzes the clinical success and complications of fibrinolytic treatment and catheter fragmentation. Based on the data available in the literature, the authors conclude that local fibrinolytic therapy with or without fragmentation is safe and effective and that in centers with trained teams it should be the first line of treatment for hemodynamically-unstable MPE.

Our results suggest that local fibrinolysis and mechanical fragmentation of hemodynamically-unstable patients with PE is a safe and effective method of treatment in a center with experience in these techniques. Adequately-designed future studies should evaluate its advantages over systemic fibrinolysis.

Conflict of Interest

The authors declare having no conflict of interest.

Acknowledgements

References

1. Hirsh U, Guyatt G, Albers GW, Harrington R, Schünemann HJ. Executive American College of Chest Physicians Evidence-Based Clinical Practice Guidelines (8th Edition). Chest. 2008;133:71S-105S.
2. Guyatt G, Schünemann HJ, Cook D, Jaeschke R, Pauker S. Applying the Grades of Recommendation for Antithrombotic and Thrombolytic Therapy: The Seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy (7th Edition). Chest. 2004;126:179S-87S.
3. Verstraete M, Miller GA, Bounameaux H, Charbonnier B, Colle JP, Lecorf G, et al. Intravenous and intrapulmonary recombinant tissue-type plasminogen activator in the treatment of acute massive pulmonary embolism. Circulation. 1988;77:353-60.
4. Torbicki A, Perrier A, Konstantinides S, Agnelli G, Galiè N, Pruszczyk P, et al. Guidelines on the diagnosis and management of acute pulmonary embolism: the Task Force for the Diagnosis and Management of Acute Pulmonary Embolism of the European Society of Cardiology (ESC). Eur Heart J. 2008;29:2276-315.
5. Tajima H, Murata S, Kumazaki T, Nakazawa K, Abe Y, Komada Y, et al. Hybrid treatment of acute massive pulmonary thromboembolism: mechanical fragmentation with a modified rotating pigtail catheter, local fibrinolytic therapy, and clot aspiration followed by systemic fibrinolytic therapy. AJR Am J Roentgenol. 2004;183:589-95.
6. De Gregorio M, Gimeno M, Alfonso R, Medrano J, Loyola S, Fava M, et al. Mechanical fragmentation and intrapulmonary fibrinolysis in the treatment of massive pulmonary embolism hemodynamic repercussions. Arch Bronconeumol. 2001;37:58-64.
7. Kuo WT, Gould MK, Louie JD, Rosenberg JK, Sze DY, Hofmann LV. Catheter-directed therapy for the treatment of massive pulmonary embolism: systematic review and meta-analysis of modern techniques. JVIR. 2009;11:1403-506
8. Miller GAH, Sutton GC, Kerr IH. Comparison of streptokinase and heparin in treatment of isolated acute massive pulmonary embolism. Br Med J. 1971;2:681-6.
9. Kucher N, Rossi E, De Rosa M, Goldhaber SZ. Massive pulmonary embolism. Circulation. 2006;113:577-82.
10. Kucher N. Catheter embolectomy for acute pulmonary embolism. Chest. 2007;132:657-63.
11. Schünemann HJ, Cook D, Grimshaw J, Liberati A, Heffner J, Tapson V, et al. Antithrombotic and thrombolytic therapy: from evidence to application: the Seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy. Chest. 2004;126:688S-96S.
12. Ramakrishnan N. Thrombolysis is not warranted in submassive pulmonary embolism: a systematic review and meta-analysis. Crit Care Resusc. 2007;9:357-63.
13. Perlroth DJ, Sanders GD, Gould MK. Effectiveness and cost-effectiveness of thrombolysis in submassive pulmonary embolism. Arch Intern Med. 2007;167:74-80.
14. Zamanian RT, Gould MK. Effectiveness and cost effectiveness of thrombolysis in patients with acute pulmonary embolism. Curr Opin Pulm Med. 2008;14:422-6.
15. Konstantinides S, Geibel A, Heusel G, Heinrich F, Kasper W, Management Strategies and Prognosis of Pulmonary Embolism Trial Investigators. Heparin plus alteplase compared with heparin alone in patients with submassive pulmonary embolism. N Engl J Med. 2002;347:1143-50.
16. De Gregorio MA, Gimeno MJ, Mainar A, Herrera M, Tobio R, Alfonso R, et al. Mechanical and enzymatic thrombolysis for massive pulmonary embolism. J Vasc Interv Radiol. 2002;13:163-9.
17. De Gregorio MA, Fava M. Fragmentation and fibrinolysis in pulmonary thromboembolism. Arch Bronconeumol. 2001;37:513.
18. Schmitz-Rode T, Kilbinger M, Günther RW. Simulated flow pattern in massive pulmonary embolism: significance for selective intrapulmonary thrombolysis. Cardiovasc Intervent Radiol. 1998;21:199-204.
19. Tapson VF, Gurbel PA, Witty LA, Pieper KS, Stack RS. Pharmacomechanical thrombolysis of experimental pulmonary emboli: rapid low dose intraembolic therapy. Chest. 1994;106:1558-62.
20. Fava M, Loyola S, Flores P, Huete I. Mechanical fragmentation and pharmacologic thrombolysis in massive pulmonary embolism. J Vasc Interv Radiol. 1997;8:261-6.
21. Nakazawa K, Tajima H, Murata S, Kumita SI, Yamamoto T, Tanaka K. Catheter fragmentation of acute massive pulmonary thromboembolism: distal embolisation and pulmonary arterial pressure elevation. Br J Radiol. 2008;81:848-54.
22. Pieri S, Agresti P. Hybrid treatment with angiographic catheter in massive pulmonary embolism: mechanical fragmentation and fibrinolysis. Radiol Med. 2007;112:837-49.
23. Zhou WZ, Shi HB, Yang ZQ, Liu S, Zhou CG, Zhao LB, et al. Value of percutanous catheter fragmentation in the management of massive pulmonary embolism. Chin Med J (Engl). 2009;122:1723-7.
24. Greenberg RK, Ouriel K, Srivastava S, Shortell C, Ivancev K, Waldman D, et-al. Mechanical versus chemical thrombolysis: an in differentiation of thrombolytic mechanisms. J Vasc Interv Radiol. 2000;11(2 Pt 1):199-205.
25. De Gregorio MA, Gamboa P, Bonilla DL, Sánchez M, Higuera MT, Medrano J, et al. Retrieval of Gunther Tulip optional vena cava filters 30 days after implantation: a prospective clinical study. J Vasc Interv Radiol. 2006;11:1781-9.
26. Lyon SM, Riojas GE, Uberoi R, Patel J, Lipp ME, Plant GR, et al. Short- and long-term retrievability of the Celect vena cava filter: results from a multi-institutional registry. J Vasc Interv Radiol. 2009;20:1441-8.
27. Pastores SM. Management of venous thromboembolism in the intensive care unit. J Crit Care. 2009;24:185-91.
28. Bandyopadhyay T, Martin I, Lahiri B. Combined thrombolysis and inferior vena caval interruption as a therapeutic approach to massive and submassive pulmonary embolism. Conn Med. 2006;70:367-70.
29. Jiménez D, Aujesky D, Díaz G, Monreal M, Otero R, Martí D, et al, RIETE Investigators. Prognostic significance of deep vein thrombosis in patients presenting with acute symptomatic pulmonary embolism. Am J Respir Crit Care Med. 2010;181:983-91.
30. Kuo WT, Van den Bosch MA, Hofmann LV, Louie JD, Kothary N, Sze DY. Catheter-directed embolectomy, fragmentation, and thrombolysis for the treatment of massive pulmonary embolism after failure of systemic thrombolysis. Chest. 2008;134:250-4.