Egyptian Journal of Radiology and Nuclear Medicine

RESEARCH

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Pharmacomechanical thrombectomy in management of pulmonary embolism

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Abstract

Background Acute pulmonary embolism is recorded as one of the most common and critical medical conditions, resulting in a notable mortality rate requiring a multidisciplinary management. In this series, we address the management of massive and sub-massive pulmonary embolism utilizing catheter-based intervention, in particular the conjunction of mechanical thrombus disruption and aspiration with pharmacological thrombolysis (pharmacomechanical thrombectomy).

Results 37 patients were diagnosed with massive and sub-massive pulmonary embolism based on the clinical and radiological findings. Pre-procedural vital parameters were obtained, including oxygen saturation, pulse rate, and blood pressure. Under continuous monitoring and conscious sedation, a pulmonary angiography via right common femoral vein access was performed for pre-procedural assessment. Pharmacomechanical thrombectomy was performed using the AngioJet Ultra System (Boston Scientific). Using the power pulse option, a fibrinolytic agent was infused into the thrombus. After 5–10 min, mechanical thrombectomy is performed with a maximum 3 passes through the thrombus. This technique is performed in the main pulmonary artery and lower branch. The procedure is repeated on the other side. The maximum duration of thrombectomy is 2–3 min on each side. Procedure success was based on improvement of vital signs and not related to post-procedure angiographic findings. All patients showed immediate improvement of vital signs (blood pressure, 02 saturation, and pulse rate) with progressive improvement over the following days. There were no procedure-related complications.

Conclusion Pharmacomechanical thrombectomy is a safe and effective technique in the treatment of massive and submassive pulmonary embolism. It can be a first-line treatment even in patients without absolute contraindication to systemic thrombolysis.

Keywords Pulmonary embolism, Pharmacomechanical thrombectomy, AngioJet ultra system

Introduction

Acute pulmonary embolism (PE) is viewed as a global risk-to-life condition with a general mortality rate totaling 30% in high-risk patients [1]. According to the International Cooperative Pulmonary Embolism Registry (ICOPER), massive PE is defined as hemodynamic instability with chronic hypotension (systolic blood pressure < 90 mm Hg) or signs of shock requiring cardiopulmonary resuscitation. Whereas submassive pulmonary embolism is when the patient is hemodynamically stable (systolic blood pressure > 90 mm Hg) inferred by right ventricular dysfunction as a sequel of increased pulmonary artery pressures' [2].

The early intervention conducted for patients with acute PE is pharmacological therapy with intravenous (IV) thrombolysis, weighting the absolute and relative contraindications. However, in patients chosen based on

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developing PE-related hemodynamic instability, invasive therapeutic strategies include mechanical thrombectomy, either percutaneous or surgical [3].

40% of type-4 or type-5 patients of the Pulmonary Embolism Severity Index (PESI) present with contraindications for both surgical embolectomy and fibrinolytic therapy; percutaneous mechanical pulmonary thrombectomy (PMPT) is considered treatment of choice [4].

In recent years, the PMT (pharmacomechanical thrombectomy) using a rheolytic thrombectomy catheter (AngioJet, Minneapolis, MN, USA) has been employed to replace thrombolysis and surgical thromboembolectomy. [5].

In our study, we address the management of massive and submassive PE utilizing catheter-based intervention, in particular the conjunction of local pharmacological thrombolysis and mechanical thrombectomy (PMT) using AngioJet rheolytic thrombectomy.

Material and methods

Patient population

In the duration between: Jan\ 2022 to Dec.\ 2023. We prospectively report on 37 patients (18 males, 19 females, mean age 67.9; years) referred to our catheterization unit with clinical picture of massive and sub-massive PE (shock, hypotension, and right ventricular dysfunction), 25 patients with massive PE presented with syncopal attack and cardiogenic shock, 12 patients with sub-massive PE presented with chest tightness and shortness of breath. All patients were clinically and laboratory investigated. Patients were not candidate for IV thrombolysis were categorized, for example (recent surgery in 13 patients and intracranial hemorrhage (ICH) in 9 patients, multiorgan injury in 11 patients and cardiac tamponade in 4 patients). In order to confirm the diagnosis, patients underwent CT (computed tomography) angiography. Technical aspects related to the procedure as well as periprocedural and post-procedural complications were collected.

CT protocol

Enhanced CT scan (CT pulmonary angiography) was performed using GE 64 slice CTV or SEIMENS (SOMATOM Definition Flash), there was bilateral emboli of the main pulmonary arteries in 28 cases and lobar branches in 9 cases. Patients were prepared for PMT.

Patient preparation

In the catheterization laboratory, pre-procedural vital parameters were obtained, including oxygen saturation, pulse rate, and blood pressure.

A color Doppler scan of the lower limbs was done to exclude DVT (deep venous thrombosis) for the decision of IVC (inferior vena cava) filter placement.

Assessment of access site (right common femoral vein) by color Doppler ultrasound. Procedure done under GA in 7 cases, conscious sedation in 24 cases, no sedation in 6 cases, with the right inguinal area was infiltrated with local anesthesia. Venogram of iliac vein and IVC using a diluted contrast media 50–70% Omnipaque 350 mg I/ml using a power injector. An 8 French 45 cm sheath introduced, pulmonary artery catheterized using pigtail, vertebral, or MPA 5–6 French. A diagnostic pulmonary angiogram was performed with hand injection (10–20 ml contrast). A 0.035 hydrophilic guide wire, Terumo or Aquatrack (Cordis), navigated to one of the pulmonary arteries. Thrombectomy catheter introduced over the wire (Solent Proxi 90 cm or Solent Omni 120 cm), AngioJet (Ultra Thrombectomy System, Boston Scientific). Both catheters are power pulse enabled, so we can infuse rTPA (Reteplase) within the thrombus. Reteplase is prepared by mixing 10 units with 100 ml of saline, so every 10 ml of saline has 1 unit of reteplase. The thrombus was infused with 2 units on each side. 10–15 min later, mechanical throbectomy started with 2–3 passes through the thrombus with a maximum duration of 2–3 min. In our study, PMT was directed to the lower lobe branches. During the procedure, we limited the time of aspiration to 7–10 s to avoid the bradyarrhythmias during a longer aspiration of embolic material. On the other hand, the non-sedated patients experienced chest pain and shortness of breath. The procedure was temporarily held until the parameters and symptoms stabilized and PMT presumed again. All patients showed obvious clinical impact directly after the procedure with improved vital signs and reduced oxygen demands. Post procedure and IVC filters were placed (Figs. 1, 2, 3).

Statistics

Resulting data were processed and further analyzed using the SPSS 20 statistical software (IBM Corp., New York, USA).). Constant variables were articulated as medians, while categorical data were articulated and interpreted in numbers and percentages.

Results

Between January 2022 and December 2023, 37 patients (18 males and 19 females) with PE were admitted to our department, of whom 12 were diagnosed with intermediate-risk PE and 25 with high-risk PE. The mean age was 67.9 years. Patients who were not candidates for IV (intravenous) thrombolysis were categorized as follows: recent surgery in 13 patients, intracranial hemorrhage

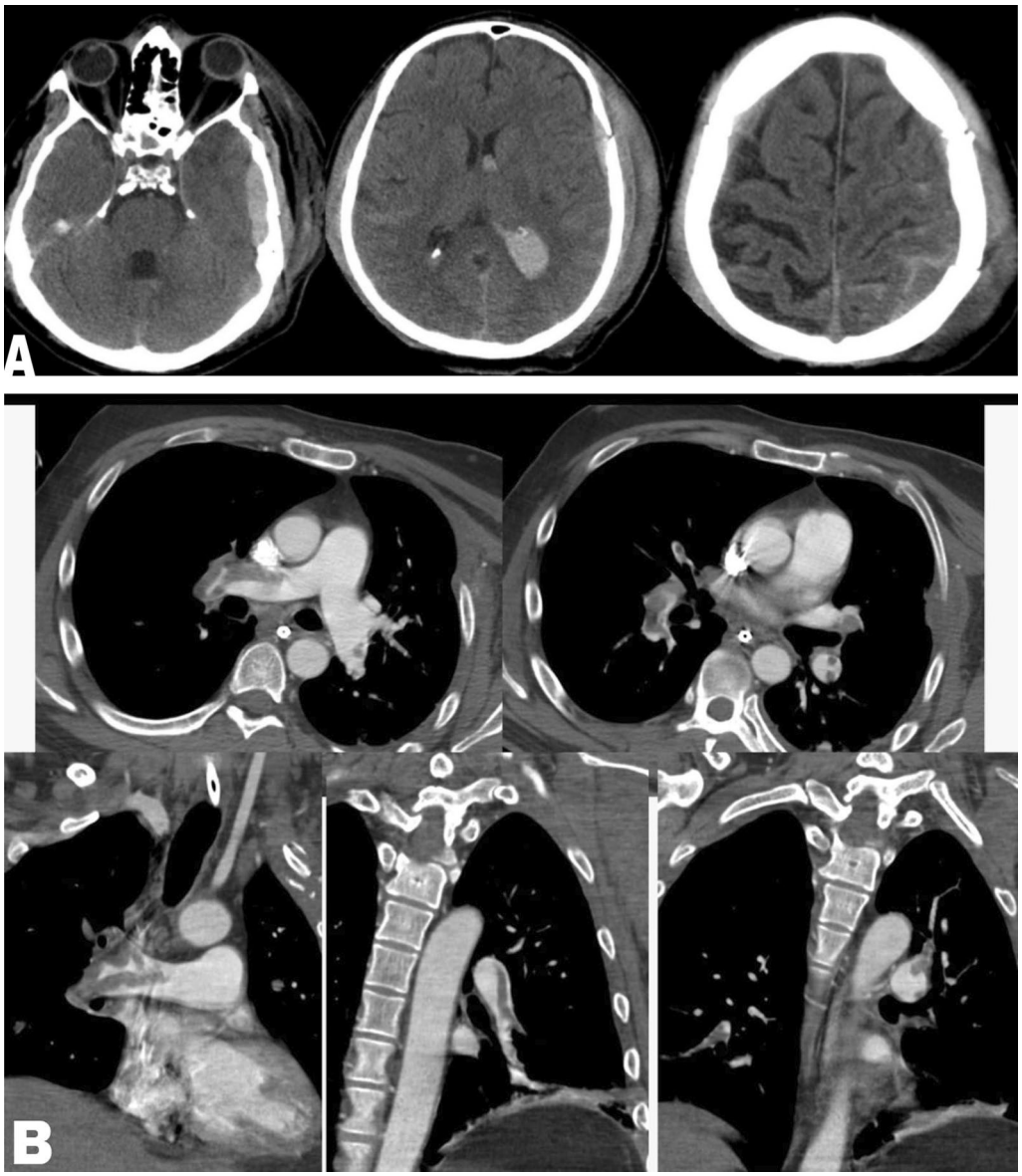
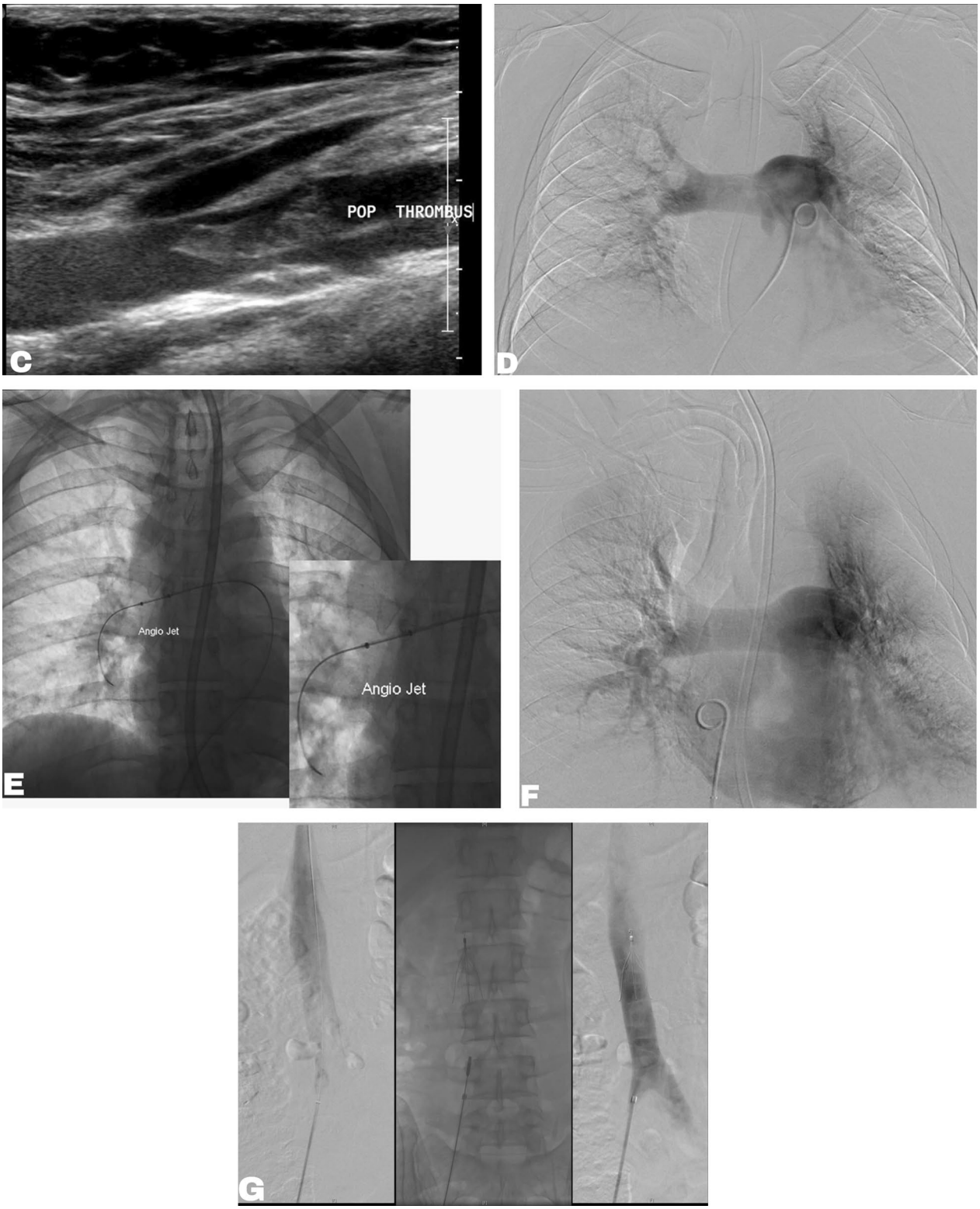


Fig. 1 25-year-old male with a history of polytrauma **A** non-contrast axial CT brain shows left temporo-parietal epidural hematoma with underlying fracture, intra-ventricular hemorrhage, and left side subarachnoid hemorrhage. **B** Contrast CT chest PE study axial and coronal revealed massive pulmonary embolism on both sides involving both main arteries and segmental branches; the patient was hemodynamically unstable; IV thrombolysis and anticoagulation are contraindicated. **C** Doppler study shows total thrombosis in the popliteal vein. **D** Pulmonary angiography confirmed the previous CT finding. **E** Angiojet catheter is inserted. **F** PMT was done and recanalization of occluded arteries was noted, and we obtained clinical success, which was defined as resolution of hypoxemia, restoration of hemodynamic stability, and survival. **G** IVC filter are inserted



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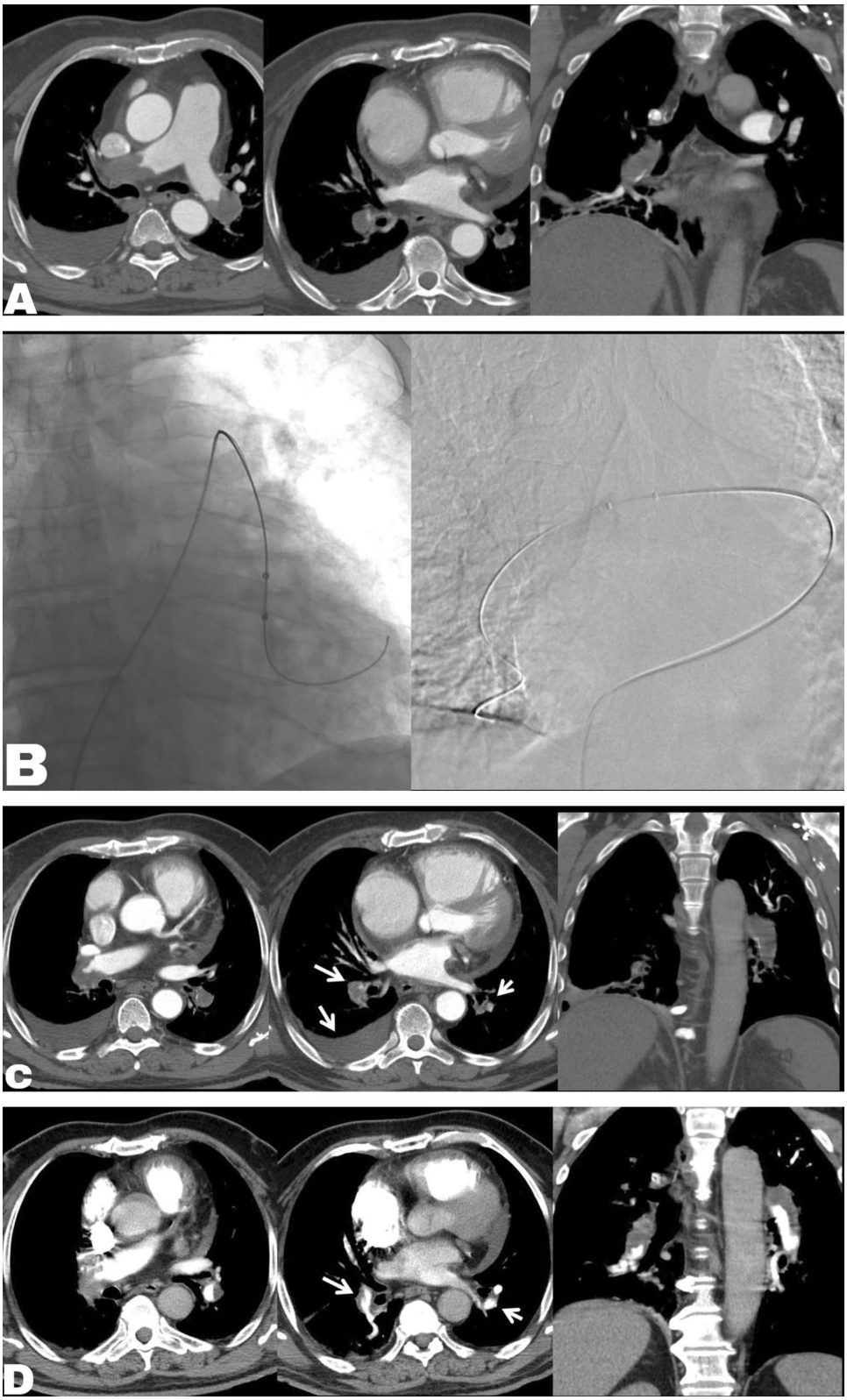

Fig. 2 60-year-old patient, **A** An axial and coronal contrast CT chest PE study shows bilateral massive PE; the patient was hemodynamically unstable; IV thrombolysis and anticoagulation are contraindicated. **B** Angiojet catheter PE is noted, and PMT was done. **C**, **D** pre- and post-procedure CT chest PE study axial and coronal images show recanalization of occluded arteries

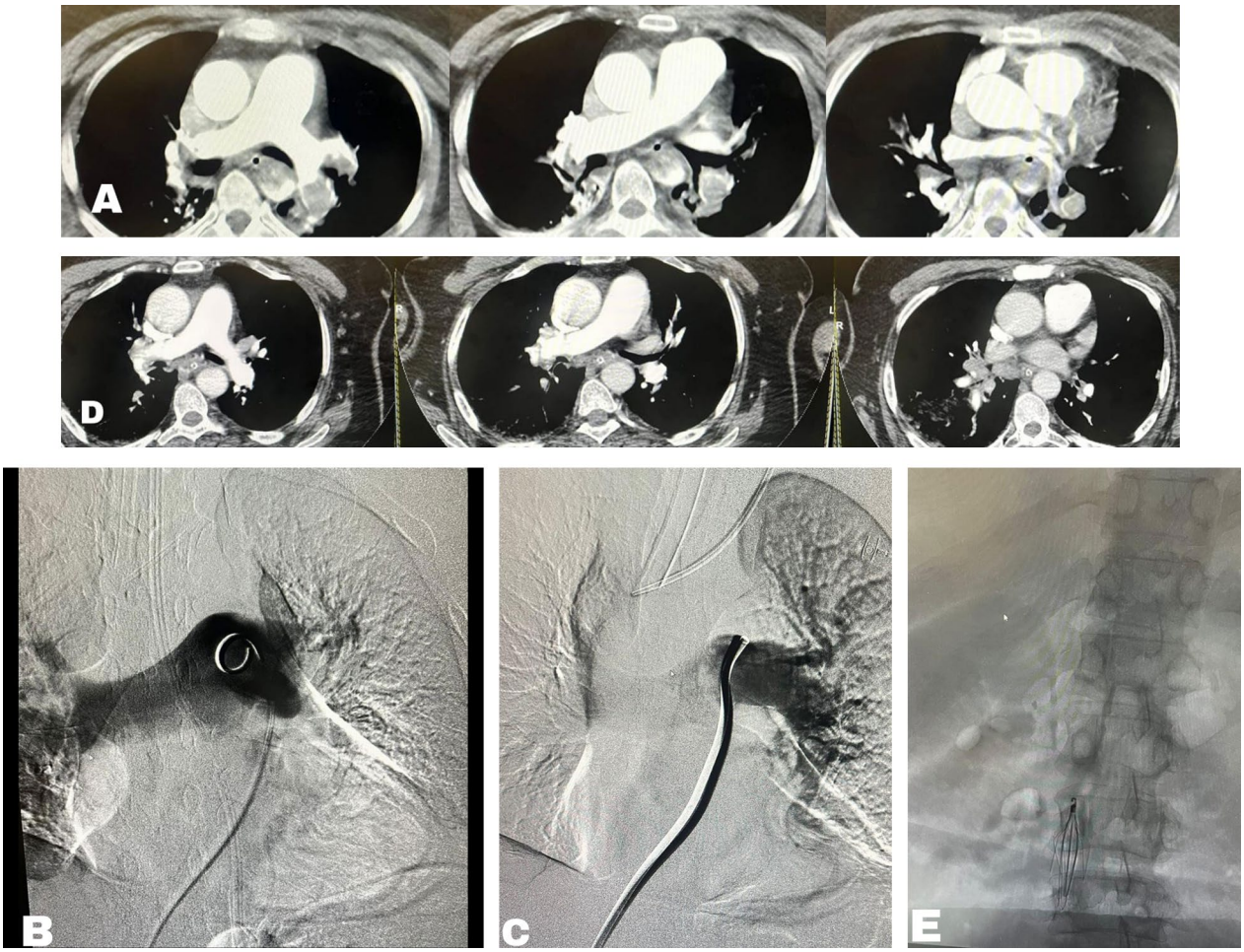

Fig. 3 54 year old patient. Result of thrombectomy in patient with occlusion of left pulmonary arteries: **A** initial contrast CT image: occlusion of the left inferior lobar arteries confirmed by angiography (**B**), **C** after thrombectomy of the inferior lobar arteries of the left lung shows recanalization in the angiograpgy image and in follow-up contrast CT (**D**), **E** IVC filter are inserted

(ICH) in 9 patients (Fig. 1), multiorgan injury in 11 patients, and cardiac tamponade in 4 patients (Table 1).

Risk factors are collected in these patients: immobilization (10 patients), recent surgery (9 patients), malignancy (3 patients), recent trauma (1 patient), and obesity (25 patients) (Table 1).

Patients diagnosed with PE presented with several symptoms, including dyspnea (37 patients), chest pain (20 patients), presyncope/syncope (25 patients), cardiac arrest (1 patient), and palpitations (4 patients). All 37 patients suffer from hypoxia and tachycardia (heart rate > 130/min) (Table 1).

Diagnostic modalities revealed right heart strain in 37 patients, right ventricular dilatation in 31 patients, troponin I > 0.01 ng/ml in 32 patients, right ventricle failure (echocardiography) in 37 patients, and occluded of both pulmonary arteries by CT angiography in 28 patients. Three lobar arteries occluded by CT angiography in 6 patients; occlusion of five lobar arteries in 3 patients; deep vein thrombosis of the lower limbs detected by Doppler ultrasonography in all patients (Table 1).

Beginning of symptoms to procedures took nearly 2–15 h: 2 h (18 patients), 3 h (6 patients), 5 h (5 patients), 10 h (3 patients), 12 h (3 patients), and 15 h (2 patients) (Table 2).

In our study, we introduced the AngioJet system to the pulmonary arteries in all patients. Mechanical thrombectomy using this device demonstrated significance efficiency in all the selected patients (technical success rate: 100%).

The procedure took from 30 to 55 min: 20 min (20 patients), 25 min (7 patients), 30 min (3 patients), 35 min (2 patients), 40 min (2 patients), 45 min (1 patient), 50 min (1 patient), and 55 min (1 patient) (Table 3).

PMPTs that were done on all patients were successful. Normalization of heart rate occurred in the first two

Table 1 All treated patients' demographic, clinical, and diagnostic information

Gender	
Male	18 (48%)
Female	19 (51%)
Age	
Mean ± SD [years]	67.9 years
PE risk factors include	
Immobilisation	10 (27%)
Recent surgery	9 (24%)
Malignancy	3 (8%)
Recent trauma	1 (3%)
Obesity	25 (67%)
Restrictions on thrombolysis usage	37 (100%)
Recent surgery	13 (35%)
Intracranial hemorrhage (ICH)	9 (24%)
Multiorgan injury	11 (29%)
Cardiac tamponade	4 (10%)
Symptoms	
Dyspnoea	37 (100%)
Chest pain	20 (54%)
Presyncope/syncope	25 (67%)
Cardiac arrest	1 (3%)
Palpitations	4 (10%)
Presentation in a clinical setting	
Intermediate-risk pulmonary embolism	12 (32%)
High-risk pulmonary embolism	25 (67%)
Hypoxia	37 (100%)
Tachycardia (heart rate > 130/min)	37 (100%)
Modes of diagnosis	
Right heart strain	37 (100%)
Right ventricular dilatation	31 (83%)
Troponin I > 0.01 ng/ml	32 (86%)
Right ventricle failure (echocardiography)	37 (100%)
Embolism of both pulmonary arteries in CT angiography	28 (75%)
3 lobar arteries occluded in CT angiography	6 (16%)
occlusion of five lobar arteries	3 (8%)
Deep vein thrombosis of the lower extremities demonstrated by sonographic examination	37 (100%)

Table 2 The process took anything from 30 to 55 min to complete

Time from onset of symptoms to the procedure (h)	Number of patients
2	18 (48%)
3	6 (16%)
5	5 (13%)
10	3 (8%)
12	3 (8%)
15	2 (6%)

Table 3 The process took between thirty to fifty-five minutes

Duration of the procedure (min)	Number of patients
20	20 (54%)
25	7 (18%)
30	3 (8%)
35	2 (6%)
40	2 (6%)
45	1 (3%)
50	1 (3%)
55	1 (3%)

hours after the procedure, while improvement of respiratory function manifested with the disappearance of dyspnea and normalization of blood gas parameters occurred two to six hours after the procedure.

Specific clinical parameters were documented before and after the PMT procedure, including blood pressure, pulse rate, oxygen saturation and concentration, and the dose of inotropic agents (if used). Most of the patients vital signs and oxygen demand improved after the procedure. Accidental radiographic findings such as ASD (atrial septal defect) were noted in one case.

Hemodynamic and vital outcomes are summarized in Table 4. Immediately following thrombectomy, the mPAP (mean pulmonary artery pressure) decreased from 31.6 ± 7.0 to 25.9 ± 7.7 mmHg. The sPAP (systolic pulmonary artery pressure) also decreased on-table from 52.2 ± 12 to 41.4 ± 12.1 mmHg. Immediately following thrombectomy, the CI (cardiac index) increased in these patients from 1.54 ± 0.61 to 1.93 ± 0.56L/min/m^2. Immediately following thrombectomy, the TPVR (total pulmonary vascular resistance) decreased from 6.33 ± 4.11 to 5.99 ± 2.87 mmHg·min/L, and heart rate decreased from 138.5 ± 17 to 88.5 ± 14.8 bpm. (Table 4).

There were no significant side effects directly associated with PMPT, such as vascular perforation or bleeding from the access site.

During the procedure, the most frequently encountered problems in patients under GA (general anesthesia) or conscious sedation were extreme fluctuation in heart rate as low as 40 bpm (beats per minute) and high as 240 bpm. On the other hand, the non-sedated patients experienced chest pain and shortness of breath. In these situations, the procedure was temporarily held until the parameters and symptoms stabilized and PMT was presumed again. Also, one of the most important adverse effects in patients managed with PMPT was bradyarrhythmia during long aspiration of pulmonary emboli. These symptoms ceased spontaneously with the discontinuation of aspiration, so we limited the time of aspiration to 7–10 s. No major adverse events

Table 4 Alterations in vital signs and hemodynamics right away after thrombectomy

Hemodynamic/vital value	Preprocedure (mean ± SD)	Post-procedure (mean ± SD)
mPAP, mmHg	31.6 ± 7.0 *n* = 28	25.8 ± 7.7 *n* = 27
sPAP, mmHg	52.2 ± 12 *n* = 29	41.4 ± 12.1 *n* = 28
Baseline sPAP ≥ 70 mmHg	77.9 ± 11 *n* = 27	59.2 ± 12.4 *n* = 27
Mean right atrial pressure, mmHg	12.6 ± 6 *n* = 32	10.0 ± 6.4 *n* = 32
Heart rate, bpm	138.5 ± 17.3 *n* = 33	88.5 ± 14.8 *n* = 33
CI, L/min/m2	2.56 ± 0.79 *n* = 29	2.56 ± 0.79 *n* = 29
Baseline CI < 2.0 L/min/m2	1.54 ± 0.61 *n* = 14	1.93 ± 0.56 *n* = 13
TPVR, mmHg·min/L	6.33 ± 4.11 *n* = 29	5.99 ± 2.87 *n* = 28

Table 5 Length of hospital stay

Duration of hospital stay (days)	Number of patients
5	25 (67%)
8	6 (16%)
12	4 (10%)
14	2 (6%)

occurred during hospitalization, such as clinical deterioration, but minor adverse events not requiring intervention or transfusion were observed in the form of hemoptysis in one patient. The overall technical and clinical success rates were 100%.

Echocardiography in all patients shows improvement in the function of the right ventricle. The duration of hospitalization was 5–14 days: 5 days (25 patients), 8 days (6 patients), 12 days (4 patients), and 14 days (2 patients) (Table 5). There were no recurrent embolisms during the 4–12 months of follow-up.

Discussion

Early treatment to restore the patency of occluded pulmonary arteries is considered the main element in decreasing the mortality rate in severe PE [1].

Risk factors are collected in these patients: immobilization, recent surgery, malignancy, recent trauma, and obesity. Also, patients diagnosed with PE presented with several symptoms, including dyspnea, chest pain, presyncope/syncope, cardiac arrest, and palpitations. All patients suffer from hypoxia and tachycardia (heart rate > 130/min), and this agrees with Liu et al. [6].

Diagnostic modalities revealed right heart strain, right ventricular dilatation, troponin I > 0.01 ng/ml, right ventricle failure (by echocardiography), occluded of both pulmonary arteries in CT angiography, and deep vein thrombosis of the lower limbs detected by Doppler ultrasonography. The beginning of symptoms and procedures took from 2 to 15 h. from the procedure took 30 to 55 min, which is near the results by Latacz et al. [5].

Although anticoagulation, thrombolysis, or surgery are the conventional treatments for pulmonary embolism, new percutaneous interventional techniques are being studied for their possible advantages in different PE groups. In order to remove, fragment, or disrupt an occlusive thrombus, or to locally administer thrombolytic drug doses that are decreased to one-third, these techniques include endovascular procedures. Individual patient outcomes from such therapies may include speedier improvements in pulmonary and systemic hemodynamics, as well as improved right ventricular function. Furthermore, in patients with high bleeding risk, percutaneous therapy may be a good substitute for conventional medicines and may help lower the death toll from significant bleeding events such as hemorrhagic strokes. Additionally, patients with absolute contraindications, such as those with a central nervous system tumor, recent stroke or surgery, or active bleeding, cannot use it. Furthermore, systemic thrombolysis is not always effective, indicating the necessity for additional therapeutic approaches [7].

In order to treat PE percutaneously, various devices are used in conjunction with a thrombolytic drug infusion to debulk the thromboembolic obstruction and restore pulmonary perfusion. These devices include rotational, rheolytic, and aspirational embolectomy, as well as CDT (catheter-directed therapies) and mechanical thrombectomy, which include catheter-directed thrombus fragmentation [7].

A low-dose thrombolytic medication is injected directly into the thrombotic pulmonary arteries using a side-hole catheter in CDT. The thrombus surface area exposed to the thrombolytic drug is so increased by CDT. To improve the effectiveness of the treatment, mechanical catheter thrombus fragmentation can also be carried out either before or during drug administration. The goal of CDT is to minimize bleeding

consequences while optimizing thrombolytic efficacy. By using a lower dose of the thrombolytic drug than systemic thrombolysis, this is enabled. Moreover, in order to increase the surface area exposed to fibrinolytics, CDT can be used in conjunction with other procedures like thrombus aspiration or fragmentation. Reports of complications from CDT include distal embolization, intraprocedural hemodynamic or respiratory decompensation, intracranial hemorrhage, non-intracranial major bleeding, and pulmonary hemorrhage [8].

Rotational thrombectomy and thrombus fragmentation: pigtail thrombus fragmentation is the simplest basic approach and is commonly utilized due to its low cost and simplicity of use. It was once responsible for around half of catheter-directed approaches, but the development of modern techniques has replaced it. Patients with a proximal occlusion who are hypotensive may benefit from these procedures because recanalization of the central embolic occlusion can quickly restore some forward flow and partially decompress the RV until additional therapy is administered [9].

Aspiration embolectomy: by clearing the thromboembolic burden and avoiding distant embolization, aspiration embolectomy attempts to restore hemodynamics [7]. Any device has benefits as well as drawbacks. As the use of these devices increases, data on their clinical value is also increasing. It is yet unknown how long-lasting and generally cost-effective they will be. We employ the AngioJet device system in our research. This modality, which has been used to treat PE, has the ability to do pharmacomechanical thrombectomy and is distinguished by its ease of use, safety, and tolerance. The AngioJet can be used as a mechanical device and as a thrombolytic in patients who are not able to tolerate pharmaceutical thrombolytic treatment because it can be utilized in both pulse mode and thrombectomy mode and double action of thrombus fragmentation and aspiration, with optional thrombolysis [10]. One benefit of treating PE with the AngioVac (Angiodynamics, USA) suction thrombectomy system is less loss of blood; it reaches additional venous vessel segments and removes thrombi; large caliber makes thrombi removal effective. Nevertheless, several drawbacks include: little data supporting this tool in PE; difficulty in maneuverability resulting in insufficient thrombus clearance; the chance of perforation rises with large caliber. An over-the-wire, single-use mechanical thrombectomy tool called the Flow Triever system (Inari Medical, Irvine, CA, USA) uses a large-bore guiding catheter (16 F, 20 F, or 24 F) along with an expanding nitinol system to reach the parietal thrombus and facilitate suction. Nitinol discs' benefits include helping to trap parietal thrombi. Improved flexibility in tortuous vessels is made possible by creative design. Large caliber permits effective thrombi removal even of larger sizes, but it has a drawback, damage to cardiovascular tissues and blood loss as a result of the high caliber. The suction aspiration system known as the INDIGO Penumbra system (Penumbra Inc., CA, USA) was initially employed in the endovascular treatment of stroke patients. The lightning-intelligent aspiration catheters CAT 8, CAT12, and CAT16 are the most recent publicly accessible Penumbra Indigo aspiration systems. Its advantage is its creative design. enhanced flexibility in tortuous vessels; less injury to the cardiocirculatory organs; less blood loss; fastest average usage time; dual mechanism that combines flow and pressure, although it has disadvantages when it comes to aspirating big blood clots [11].

The balance between efficacy and safety must be taken seriously when deciding whether to perform a percutaneous intervention for PE and when selecting the procedure. This decision-making process is difficult, though, because of the considerable variation in patient characteristics, methods used, and clinical outcomes amongst researchers. Based on the current evidence, catheter-directed treatments have the potential to accomplish hemodynamic stabilization, provided that the operator has the necessary skills. However, the results may differ based on the patient's presentation (high vs. moderate risk) and baseline features (e.g., chronic renal disease, bleeding risk) [7].

In respect to the directives of the European Society of Cardiology, shock and systemic hypotension are signs of urgent thrombolysis in patients with acute PE [1, 3]. The American College of Chest Physicians advises endovascular procedure only in patients with contraindications for fibrinolysis, mainly those with a high risk of bleeding [12], while the European Society of Cardiology recommends the endovascular approach as an alternative to surgical embolectomy in patients with failed thrombolysis [3]. Our patients were all not candidates for IV thrombolysis due to recent surgery in 13 patients, intracranial hemorrhage (ICH) in 9 patients, multiorgan injury in 11 patients, and cardiac tamponade in 4 patients.

The efficacy of this procedure (PMPT) by the AngioJet device system is based on the fact that mechanical fragmentation of the embolus raises the chance of recanalization of the pulmonary artery. Moreover, the dose of a fibrinolytic agent that is directly directed to the pulmonary arteries is decreased, lessening the frequency of the complications of bleeding [13, 14]. However, in some hospitals, PMPT is considered the procedure of choice, even though systemic thrombolysis and surgical embolectomy remain essential and effective tools [4, 15]. It has been established that the clinical success of PMPT

is primarily associated with recanalization of pulmonary arteries, and this agrees with our study. [16].

We observed that all our patients had a normalized heart rate during the first two hours following the procedure. Improvement of respiratory function manifested with the disappearance of dyspnea, and normalization of blood gas parameters occurred 2–6 h following PMPT. Most of the patients vital signs and oxygen demand improved after the procedure, and this agrees with Lauder et al. [17].

Other studies showed that the determination of completing the procedure should be based on the clinical and not angiographic result; we finished PMPT once clinical improvement of the patient is witnessed, irrespective of the angiographic finding of the pulmonary circulation. This is based on the fact that thrombectomy of distal pulmonary vessels is linked to an especially high risk of life-threatening technical failures [2].

We found some authors using local pharmacological thrombolysis after PMPT; for example, Lee et al. [18] submitted the outcome of that management process in 91 patients demonstrating intermediate-risk PE. They administered alteplase, and patients showed clinical improvement. This observation suggests that low-dose local thrombolysis after PMPT can be an additional treatment of notable effect. In our work, we don't do such management, but we are planning to do it in our next research.

Other studies have found that PMPT in high- and intermediate-risk PE is characterized by safety and effectiveness, and the risk of dangerous adverse effects is rather lower than that after fibrinolytic therapy, and this agrees with our observations [2, 19]. Bradyarrhythmia linked to long aspirations of embolic material is a well-known problem. This complication was seen in 15% of patients managed by other studies [20, 21]. Short aspirations seem to be the best way to avoid these complications. It is not yet clear which factors trigger bradyarrhythmias. Some authors blame hemolysis-related hyperkalemia, adenosine, or a spasm of arteries caused by nitric oxide sequestrated in the pulmonary circulation [22]. In our study, we limited the time of aspiration to 7–10 s. Other studies reported some other adverse events associated with the use of the AngioJet system, such as hemoptysis, renal failure, and peripheral embolization [20]. Still others found this endovascular procedure to be safer [3, 15]. In our patients, except for one patient who complained of hemoptysis not requiring intervention or transfusion, there were no serious complications.

Echocardiography in all patients started normalizing the function of the right ventricle. The duration of the hospitalization was 5–14 days. There were no recurrent thromboembolic events during the 4–12 months of follow-up, and this agrees with Latacz et al. [5].

Our study revealed that PMPT can be used as an alternative to standard management in patients with contraindications for fibrinolysis or surgical embolectomy, with a technical success rate of 100%.

Conclusion

Percutaneous rheolytic thrombectomy applying the AngioJet catheter may be an effective option for treating patients with massive or submassive pulmonary embolism with rapid and significant hemodynamic improvement and satisfactory outcome at early and long-term follow-up. Greater laboratory and operator experience produces better clinical results.

Limitations of the study

A relatively small sample size, a single-center study, and no control group are the main limitations of this study, but the standardization of the protocol of this procedure for PMPT could be a strong point of our study.

Abbreviations

PE	Pulmonary embolism
ICOPER	International Cooperative Pulmonary Embolism Registry
PESI	Pulmonary Embolism Severity Index
PMPT	Percutaneous mechanical pulmonary thrombectomy
PMT	Pharmacomechanical thrombectomy
ICH	Intracranial hemorrhage
CT	Computed tomography
DVT	Deep venous thrombosis
IV	Intravenous
IVC	Inferior vena cava
rTPA	Reteplase
GA	General anesthesia
Bpm	Beats per minute
ASD	Atrial septal defect
mPAP	Mean pulmonary artery pressure
sPAP	Systolic pulmonary artery pressure
CI	Cardiac index
TPVR	Total pulmonary vascular resistance
SD	Standard deviation
CDT	Catheter-directed therapies

Acknowledgements

Not applicable.

Author contributions

AH analyzed and interpreted the patient data. MH performed the CT images and was a major contributor in writing the manuscript. AT & AA performed the statistics, WE revised the results, and all authors read and approved the final manuscript.

Funding

The authors declare that they have no funding.

Availability of data and materials

Not applicable.

Declarations

Ethics approval and consent to participate

This research was approved by the Non-invasive Clinical Research Ethics Committee of Mansoura University, IRB R.24.06..2678.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

Received: 27 June 2024 Accepted: 6 September 2024
Published online: 17 September 2024

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