Mechanical Thrombectomy, Artificial Intelligence and the Activation of a Pulmonary Embolism Response Team

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Introduction

Pulmonary embolism (PE) is associated with high morbidity and mortality. Right heart strain and time from triage to diagnosis have both been shown to be independent predictors of mortality in cases of acute PE_{1-3}. While the use of mechanical thrombectomy remains controversial in some cases, it has been shown to be safe and technically effective at treating massive and submassive PEs while rapidly reducing right heart strain, with low rates of adverse events such as major bleeding$_{4-5}$.

To maximize the rapid improvement in right ventricular function that mechanical thrombectomy provides, it should be performed within the shortest time frame possible. Standard practice often entails diagnosis with CT angiography followed by notification of the responsible clinical provider by the reading radiologist. In addition, it may or may not involve a multidisciplinary pulmonary embolism response team (PERT). Here, an artificial intelligence algorithm was implemented to analyze CT angiograms and notify all members of a multidisciplinary PERT, including interventionalists, of PE cases with CT evidence of right heart strain. Notification occurs directly, through a smartphone based application. We hypothesize that this will decrease time from CT angiogram to mechanical thrombectomy and aim to describe the initial clinical experience with the use of this alternative workflow.

Materials and Methods

Mechanical pulmonary arterial thrombectomies performed for acute PE over a four year period were reviewed. Cases which were evaluated with CT angiogram prior to intervention were included, while those evaluated with VQ scan and/or echocardiography alone were excluded, given the algorithm implemented operates through identification of potential thrombectomy cases based on CT angiogram findings only. One patient in each group presented via transfer from outside hospitals. These cases were excluded given the times from imaging to thrombectomy were heavily skewed by the logistics of transportation. Use of the algorithm to directly notify PERT members began in early 2022. This time point was used to divide cases into two groups, those presenting prior to and following implementation. Time of CT angiogram acquisition, time of notification of a clinical provider by the reading diagnostic radiologist and time of thrombectomy were gathered and used to compare times to thrombectomy and time from imaging to notification of a clinical provider between the two groups. National Early Warning Score (NEWS) prior to and following thrombectomy, patient mortality within 30 days of thrombectomy, total length of hospital stay and number of ICU days were also collected. Two patients in the post-intervention group died within 30 days of thrombectomy and were excluded from the calculations of hospital and ICU days.

Results

- A total of 13 patients met inclusion criteria
- 10 patients presented through the emergency department and 3 presented as inpatients.
- All cases demonstrated CT evidence of right heart strain.
- Implementation of the algorithm was associated with a decrease in time from CT angiography to mechanical thrombectomy of 7.0 hours.

Table 1: Before and After Implementation of Direct Notification of PERT by Algorithm

	Pre-Intervention	Post-Intervention
N	6	7
Age (mean; range)	53; 36-71	60; 25-84
Sex		
Male	3	4
Female	3	3
Setting		
Emergency Department	5	5
Inpatient	1	2
Time from imaging to thrombectomy (hours)	**17.1 ± 7.9**	**10.1 ± 9.7**
Time from imaging to notification of clinical provider (hours)	0.8 ± 0.8	0.5 ± 0.2
NEWS Pre-Thrombectomy	6 ± 2	6 ± 3
NEWS Post-Thrombectomy	4 ± 2	4 ± 2
Hospital Stay (days)	17 ± 11.5	14 ± 8.0
ICU Stay (days)	13 ± 13.5	10 ± 9.9
30-day mortality	0/6 (0.0 %)	2/7 (29%)

Data are mean ± SD or n unless specified otherwise.

Figure 1. CT angiograms are screened for cases with evidence of PE and right heart strain

Figure 2. Multiple bilateral filling defects and lack of parenchymal perfusion, consistent with PE, during thrombectomy, following direct notification of PERT

Discussion

Right heart strain and time from triage to diagnosis have both been shown to be independent predictors of mortality in cases of acute PE_{1-3}. Specialists who make up PERTs are essential in rapid assessment and decreasing time to thrombectomy for appropriate patients. This pilot study suggests that the use of an algorithm to immediately analyze CT angiograms and directly notify all members of a PERT of cases with evidence of PE and right heart strain may reduce time from imaging to thrombectomy. We believe that the driving force behind this difference centers around reducing the time to PERT activation. The difference in times from imaging to notification of a clinical provider were relatively similar (0.8 hr vs. 0.5 hr) and accounted for a small proportion of the overall time from imaging to thrombectomy. Therefore, presumably the observed difference in overall time from imaging to thrombectomy relates primarily to the activation of the full PERT in a timely manner rather than notification of a clinical provider by the diagnostic radiologist.

Discussion continued

Possible reasons for this include lack of widespread familiarity with which cases require PERT evaluation, mechanical thrombectomy itself, and the data regarding its clinical benefits. Given institutional bias favoring mechanical thrombectomy, only these cases were included, however similar consideration should be given to other methods of catheter directed treatment of PE. Limitations include the inherent accuracy of the algorithm, outside the scope of this discussion and requirement of CT angiogram rather than VQ scan and/or echocardiography alone. Future directions, along with expansion of the cohorts, should include assessment of the clinical significance of the difference observed (7 hours) in time to thrombectomy between the two groups.

Conclusions

Initial clinical experience with the use of an artificial intelligence algorithm suggests it may reduce time from initial imaging to mechanical pulmonary arterial thrombectomy by screening CT angiograms and directly notifying a PERT of potential candidates.

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