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Original Article

Catheter-Directed Therapies for Deep Vein Thrombosis and Pulmonary Embolism: Nationwide Trends in Medicare Part B Patients from 2015 to 2021

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Abstract

Background Nationwide trends in the utilization of catheter-directed therapies for deep vein thrombosis and pulmonary embolism in the Medicare population are essential as they represent a major health care challenge. The annual incidence and mortality with venous thromboembolism are around 900,000 and 60,000 to 100,000 patients, respectively, in the United States.

Methods Data were acquired from the Data.CMS.gov website on Physician/Supplier Procedure Summary with a list of Medicare Part B fee-for-service claims from 2015 to 2021. Current Procedural Terminology codes 37187 (percutaneous venous mechanical thrombectomy) and 37212 (thrombolytic venous therapy) were queried for deep vein thrombosis. Similarly, Current Procedural Terminology codes 37184 (percutaneous arterial mechanical thrombectomy) and 37211 (thrombolytic arterial therapy) were queried for pulmonary embolism. Annual procedure counts, site of service, and self-reported specialty of the operator were recorded.

Results Overall, there was a trend toward increasing utilization of thrombectomy and decreasing utilization of thrombolysis procedures for both deep vein thrombosis and pulmonary embolism. Radiologists performed the majority of the catheter-directed therapy interventions for deep vein thrombosis, while radiologists and surgeons performed a similar number of catheter-directed therapy procedures for pulmonary embolism. Cardiologists were third in the catheter-directed therapy procedure count for both deep vein thrombosis and pulmonary embolism.

Conclusion An analysis of nationwide trends from 2015 to 2021 suggests increasing utilization of thrombectomy starting in 2020 when compared to thrombolysis for catheter-directed therapies for both deep vein thrombosis and pulmonary embolism procedures. Newer thrombectomy technologies may be one of the drivers of this shift from thrombolysis to thrombectomy.

Keywords
- catheter-directed therapy
- deep vein thrombosis
- pulmonary embolism
- thrombectomy
- thrombolysis

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Background

Deep vein thrombosis (DVT) and pulmonary embolism (PE) represent major health care challenges and, collectively, venous thromboembolism (VTE) annual incidence is estimated to be as much as 900,000 patients with annual mortality of 60,000 to 100,000 in the United States.[1] The first-line treatment for acute DVT or PE involves systemic blood thinners such as heparin, direct oral anticoagulants (DOAC), and warfarin (Coumadin).[2] Nevertheless, systemic anticoagulation therapy has significant limitations in its safety and efficacy with significant risks of both short-term therapy failure and long-term health sequela.[2–5]

These shortcomings of systemic anticoagulation led to the development of endovascular approaches for the management of VTE, via both pharmacological thrombolysis and mechanical thrombectomy, collectively referred to as catheter-directed therapies (CDT). In this article, we analyze nationwide trends in minimally invasive CDT for thrombectomy and thrombolysis for the treatment of both DVT and PE. A comparison between thrombectomy and thrombolysis CDT procedures demonstrating utilization trends for the treatment of DVT and PE and their relative market share among different specialties is also discussed.

Methods

Study Design

This retrospective study was performed using Medicare administrative claims data. Data were acquired from the Data.CMS.gov website on Physician/Supplier Procedure Summary (PSPS) that provides a list of Medicare part B fee-for-service (FFS) claims for each calendar year from 2015 to 2021.

Downloaded data were filtered by individual Current Procedural Terminology (CPT) codes, and analyzed using Microsoft Excel software (Microsoft 365, Redmond, WA). The total submitted annual volume (SUBMITTED_SERVICE_CNT) for billable CDT was analyzed. Of note, this database entry for SUBMITTED_SERVICE_CNT only provides data for sites with at least 11 submitted services; sites with annual service counts lower than 11 are not reported.

For CDT treatments of DVT, two billable CPT codes were identified for two procedures: percutaneous venous mechanical thrombectomy (CPT code 37187) and thrombolytic venous therapy (CPT code 37212).

For CDT treatments of PE, two billable CPT codes were identified for two procedures: arterial mechanical thrombectomy (CPT code 37184) and thrombolytic arterial therapy (CPT code 37211).

Service count data were collected by place of service (POS) and region of service (ROS) to better understand the nationwide trends. POS indicated whether these procedures were performed in an inpatient (inpatient hospital) or an outpatient setting (physician office, outpatient hospital, emergency room, or ambulatory surgical centers). ROS classified service counts based on states classified as belonging to the Midwest, South, West, and East.

Results were also stratified by operator specialty, namely, radiology (diagnostic and interventional), cardiology (cardiologists, interventional cardiologists, and internal medicine), surgery (general, vascular, thoracic, cardiac, and neurosurgery), and other (emergency medicine, critical care, and pulmonology).

Results

►**Figs. 1** and **2** present the raw procedure counts for thrombectomy and thrombolysis procedures in the years 2015 to 2021 in treatment of DVT and PE, respectively. For DVT patients, more thrombectomy procedures were performed than thrombolysis (►**Fig. 1**). Also, there is a pertinent trend with increasing thrombectomy procedures starting in 2019 along with a relative reduction in thrombolysis procedures

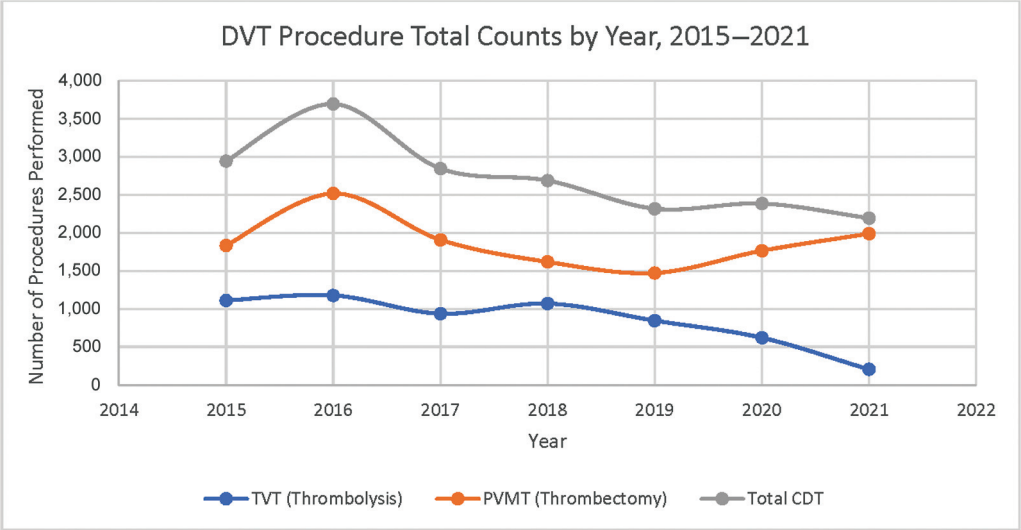


Fig. 1 Plots of deep vein thrombosis (DVT) procedure counts during the years 2015 to 2021, for percutaneous venous mechanical thrombectomy (VMT) and thrombolytic venous therapy (TVT) along with the combined procedure counts for VMT and TVT catheter-directed therapy (CDT). PVMT, percutaneous venous mechanical thrombectomy.

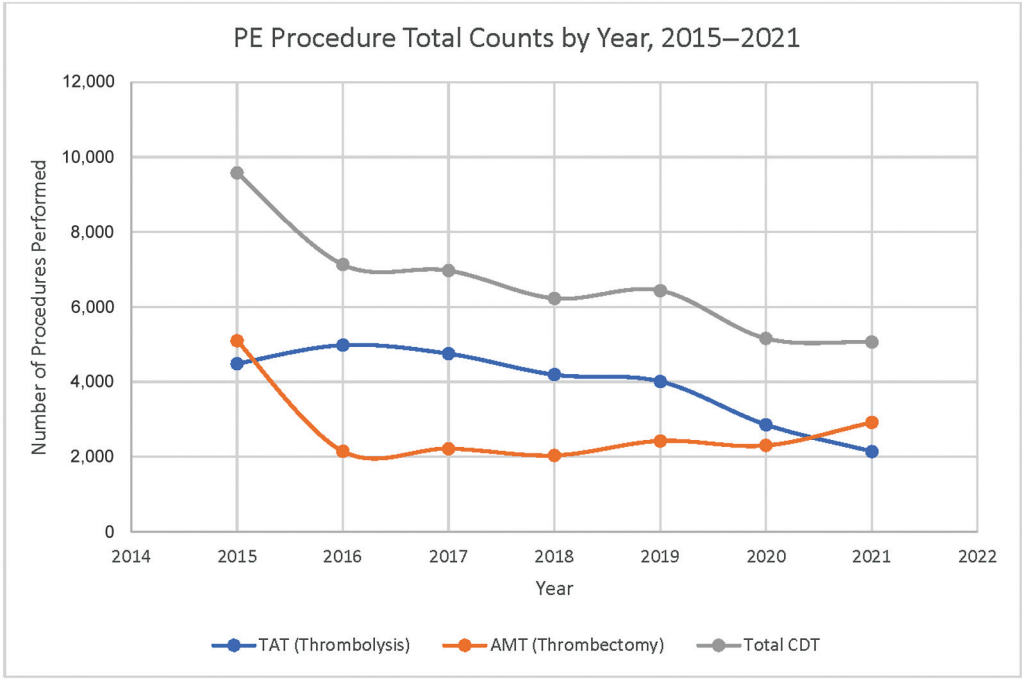


Fig. 2 Plots of pulmonary embolism (PE) procedure counts during the years 2015 to 2021, for arterial mechanical thrombectomy (AMT) and thrombolytic arterial therapy (TAT) along with the combined AMT and TAT catheter-directed therapy (CDT).

observed from 2018 onward. On the other hand, for PE CDT, more thrombolysis procedures were performed compared to thrombectomy during 2016 to 2020, with a downward trend seen starting from 2019 (►**Fig. 2**). Thrombectomy procedure counts were relatively steady during 2016 to 2020, with a small upward trend observed from 2020. Note that when the total number of CDT procedures peaked in 2016 (see ►**Fig. 1**), thrombolysis comprised 31.87%, while thrombectomy was at 68.13%. However, in 2021, thrombolysis procedures were only 9.3%, while thrombectomy increased to 90.7% of the total CDT procedures. On the other hand, for PE procedures, the ratios have remained somewhat constant from 46.79% thrombolysis and 53.21% thrombectomy in 2015 to 42.34% thrombolysis and 57.66% thrombectomy in 2021, with about a 5% increase in thrombectomy procedures over 2015 to 2021.

►**Fig. 3** presents a comparison of the different medical specialties performing CDT for DVT. The majority of CDT procedures for DVT were performed by radiology (including both diagnostic and interventional radiologists), followed by surgery and cardiology (►**Fig. 3A**). Radiology performed more thrombectomy procedures than thrombolysis over 2015 to 2021 (►**Fig. 3B**). Similar to the global trend in procedure volumes, radiologists performed more thrombectomy procedures for DVT starting in 2019 along with a relative reduction in thrombolysis procedures observed from 2018. However, during 2017 to 2020 the majority of DVT procedures for both thrombolysis and thrombectomy were still being performed by radiologists (62.38 and 41.32%, respectively) when compared to surgeons (18.88 and 33.35%, respectively) or cardiologists (11.85 and 9.69%, respectively). However, the data indicate a steady increase in DVT CDT performed by surgeons by about 14%, while the radiologist-performed procedures declined by about 21% during 2017 to 2020, with the reduction in CDT starting in 2019.

►**Fig. 4** presents a comparison of PE CDT procedures for different medical specialties. Radiologists and surgeons performed similar numbers of PE CDT procedures, followed by cardiologists (►**Fig. 4A**). All three specialties were performing a similar number of PE CDT procedures by 2021 as shown in ►**Fig. 4A**. As opposed to CDT for DVT, radiologists performed more thrombolysis procedures for PE from 2016 to 2020, with thrombectomy procedures edging higher in 2021 (►**Fig. 4B**). Similar to the global trend in procedure volumes, radiologists performed more thrombectomy procedures for PE starting in 2020 along with a relative reduction in thrombolysis procedures observed from 2019. The data also indicate that surgeons perform more PE CDT than cardiologists since both mechanical thrombectomy and embolectomy are included in CPT code 37184. The percentage of CDT procedures performed by specialty providers for both DVT and PE in 2015 and 2021 are compared in ►**Table 1**. The specialty performing the largest percentage of procedures is indicated in bold in the table.

Most CDT procedures were performed in an inpatient setting for both DVT and PE, shown in ►**Figs. 5A** and **6A**, respectively. In the outpatient setting, there were a larger number of DVT procedures performed compared to PE procedures. The outpatient setting includes both outpatient visits to a hospital site of service (POS 22) and office-based lab (OBL)/ambulatory surgery center (ASC) (POS 11/24). Most outpatient DVT or PE procedures are performed at a hospital site of service, which in most cases include 23-hour post-procedural observation. A comparison of thrombolysis

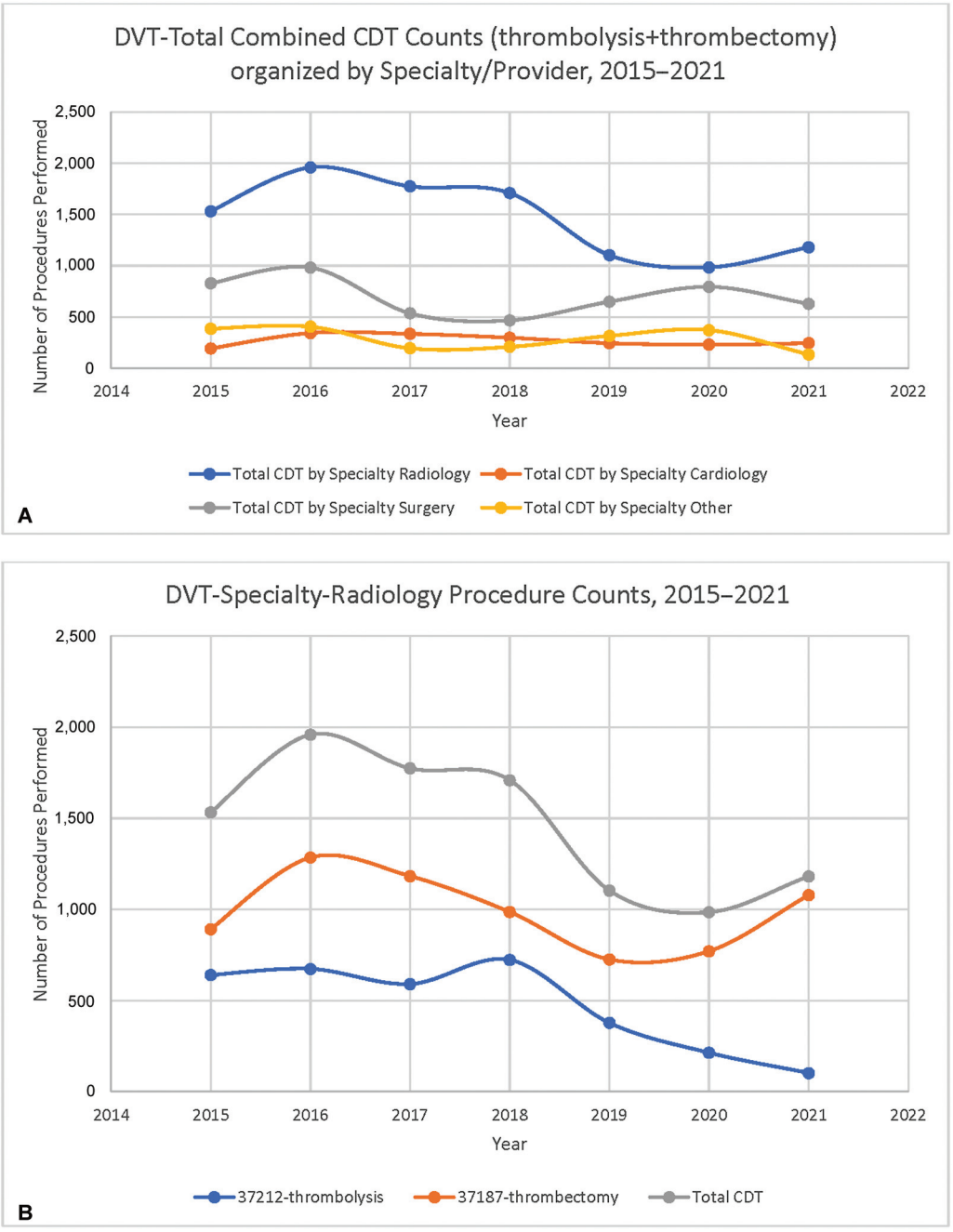


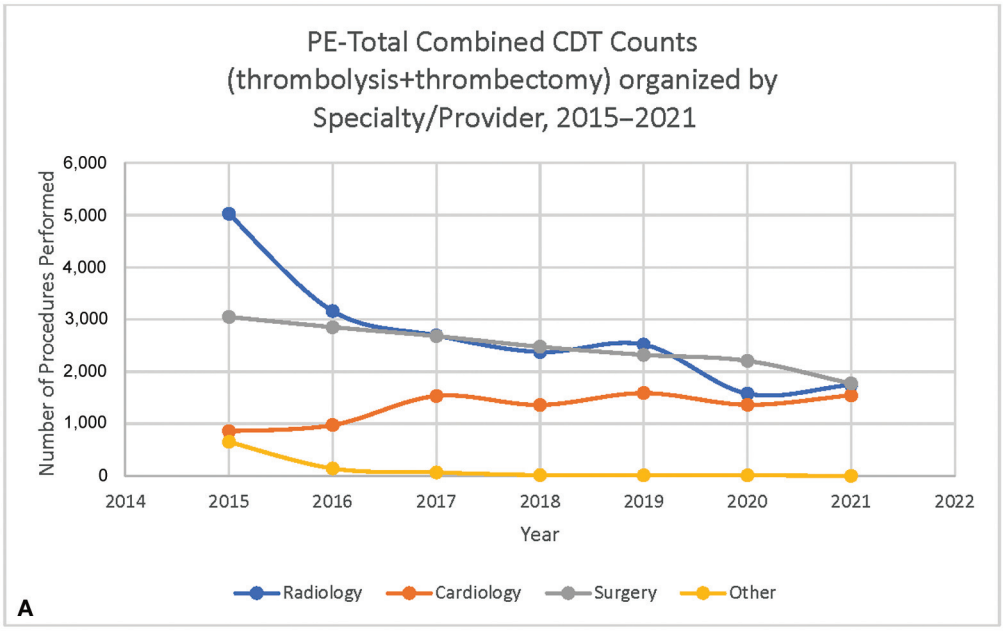
Fig. 3 Comparison plots of (**A**) different medical specialties performing deep vein thrombosis (DVT) catheter-directed therapy (CDT) during 2015 to 2021 with the total counts for both thrombolysis and thrombectomy and (**B**) radiologists performing thrombolysis versus thrombectomy.

versus thrombectomy procedures performed in an inpatient setting indicates an overall declining trend in the number of thrombolysis procedures from 2015 to 2021 (►**Fig. 5B**). On the other hand, inpatient thrombectomy procedures demonstrate an increasing trend starting in 2019 (►**Fig. 5B**). For inpatient PE CDT procedures, thrombectomy remained relatively stable and lower than thrombolysis during 2016 to 2020, with both reaching a similar level in 2021.

ROS data analyzed indicated that a large majority of the DVT and PE procedures were performed in the South region. The Midwest, East, and West regions reported similar numbers of DVT and PE CDT procedures over 2015 to 2021.

Discussion

CDTs have demonstrated reduction in symptoms and improved quality of life in the treatment of iliofemoral DVT patients who have poor outcomes with DOAC therapy alone.[6] CDT has also improved long-term survival with lower complication rate in submassive PE patients when compared to anticoagulation alone.[7] However, large prospective clinical trial data supporting CDT are lacking. In fact, the Acute venous Thrombosis: Thrombus Removal with Adjunctive Catheter-directed Thrombolysis (ATTRACT) clinical trial found that addition of CDT to anticoagulation did not lower the risk of postthrombotic syndrome in patients with acute



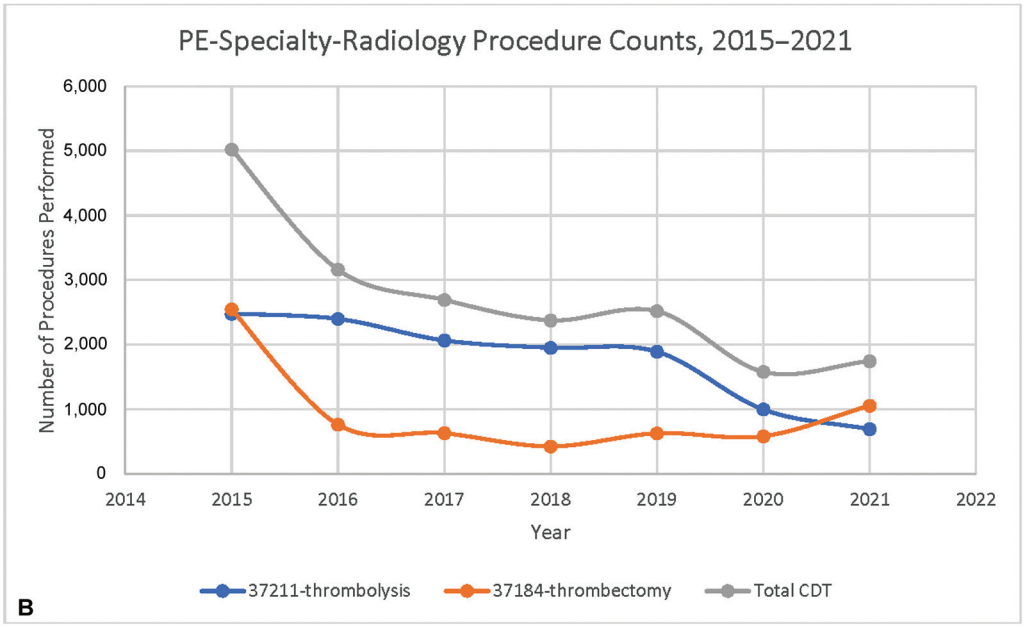


Fig. 4 Comparison plots of (**A**) different medical specialties performing pulmonary embolism (PE) catheter-directed therapy (CDT) during 2015 to 2021 with the total counts for both thrombolysis and thrombectomy and (**B**) radiologists performing thrombolysis versus thrombectomy.

proximal DVT and increased the risk of major bleeding relative to only anticoagulation therapy.[8] A factor for the significant drop in DVT procedures from 2016 to 2017 and the downward trend in the overall utilization of CDT for DVT (see ►**Fig. 1**) and PE (see ►**Fig. 2**) from 2017 to 2021 could be due to the conclusions from the ATTRACT trial.[8] In addition, the lack of randomized controlled trials justifying the need for CDT could be another factor in its decreased utilization. Despite these mixed results, the medical devices industry continues to invest in new technologies for CDT.

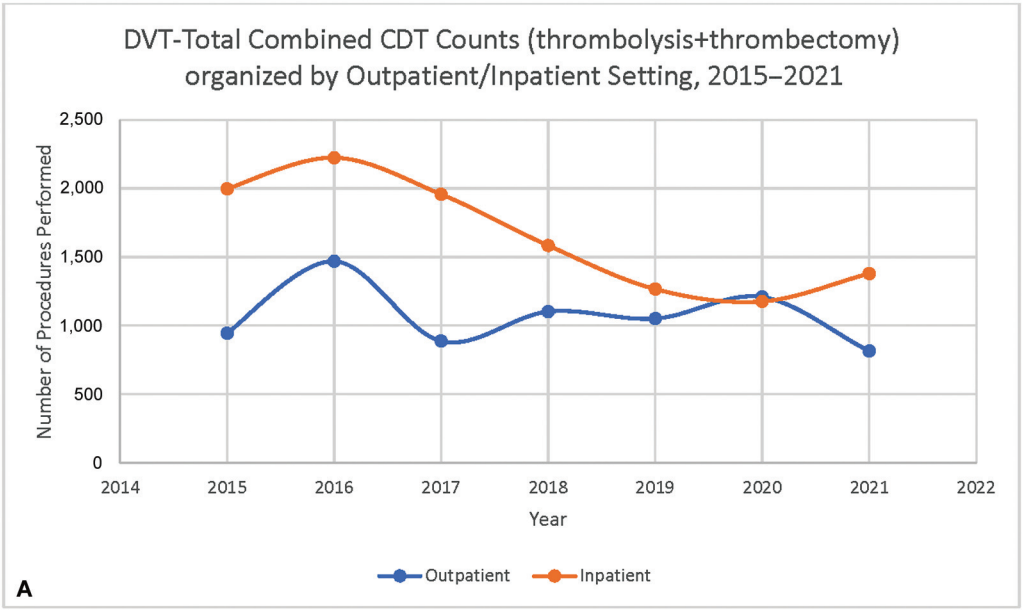
In particular, there has been introduction, development, and marketing of newer technologies geared toward thrombectomy.[9,10] In theory, thrombectomy enables immediate clot removal, minimizes bleeding risk, and mitigates the need for critical postprocedural care. Limited literature indicates that thrombectomy alone may enable faster treatment times and reduce complications since thrombolytic agents are not utilized.[11] However, the bulk of current literature does not indicate superior efficacy or safety of thrombectomy compared with thrombolysis.[12,13]

Nevertheless, this analysis of nationwide trends from 2015 to 2021 appears to suggest increasing utilization of thrombectomy procedures starting in 2020 and decreasing utilization of thrombolysis procedures for CDT for both DVT and PE procedures (►**Figs. 1** and **2**). This trend toward thrombectomy may be primarily driven by medical device development[9,10] and innovation rather than clinical data demonstrating superior outcomes.

Table 1 Comparison of the percentage of CDT procedures performed by specialty in 2015 and 2021

	Thrombolysis				Thrombectomy			
	DVT		PE		DVT		PE	
	2015	2021	2015	2021	2015	2021	2015	2021
Radiology	**57.71%**	**50.49%**	**55.24%**	32.2%	**48.66%**	**54.2%**	**49.93%**	36.15%
Cardiology	10.01%	23.04%	10.95%	**36.35%**	4.53%	10.01%	7.2%	26.25%
Surgery	20.92%	7.35%	33.54%	31.45%	32.57%	30.92%	30.28%	**37.59%**
Other	11.36%	19.12%	0.27%	0	14.24%	4.88%	12.59%	0

Abbreviations: CDT, catheter-directed therapy; DVT, deep vein thrombosis; PE, pulmonary embolism.
Note: The specialty performing the largest number of procedures in 2015 and 2021 are indicated by the bolded font.



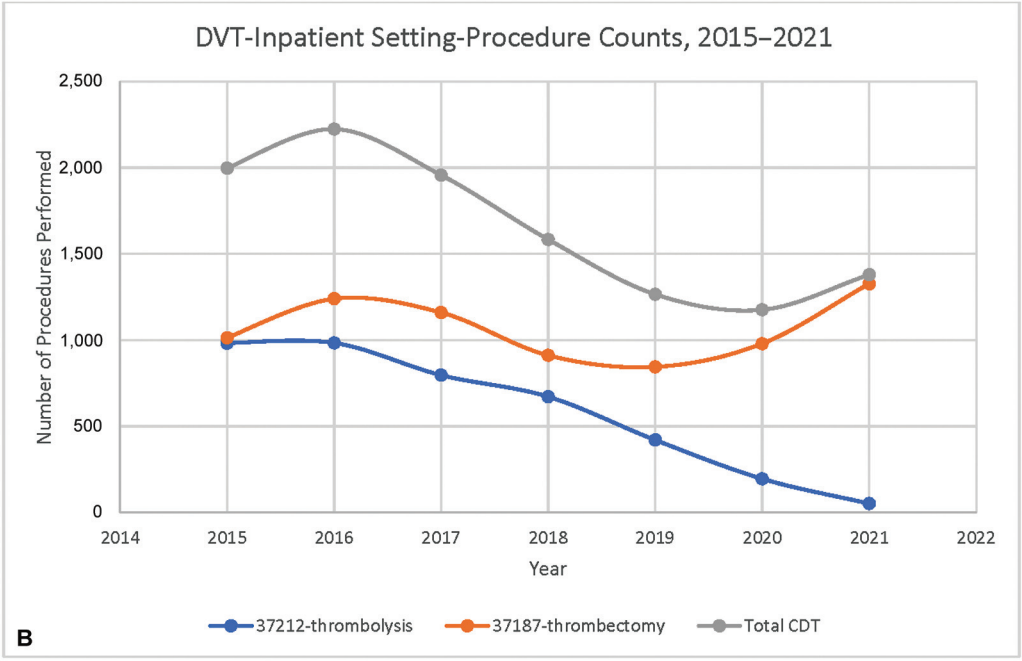


Fig. 5 (**A**) Combined catheter-directed therapy (CDT) procedure counts for inpatient versus outpatient deep vein thrombosis (DVT) procedures and (**B**) inpatient procedures stratified by thrombolysis, thrombectomy, and combined CDT.

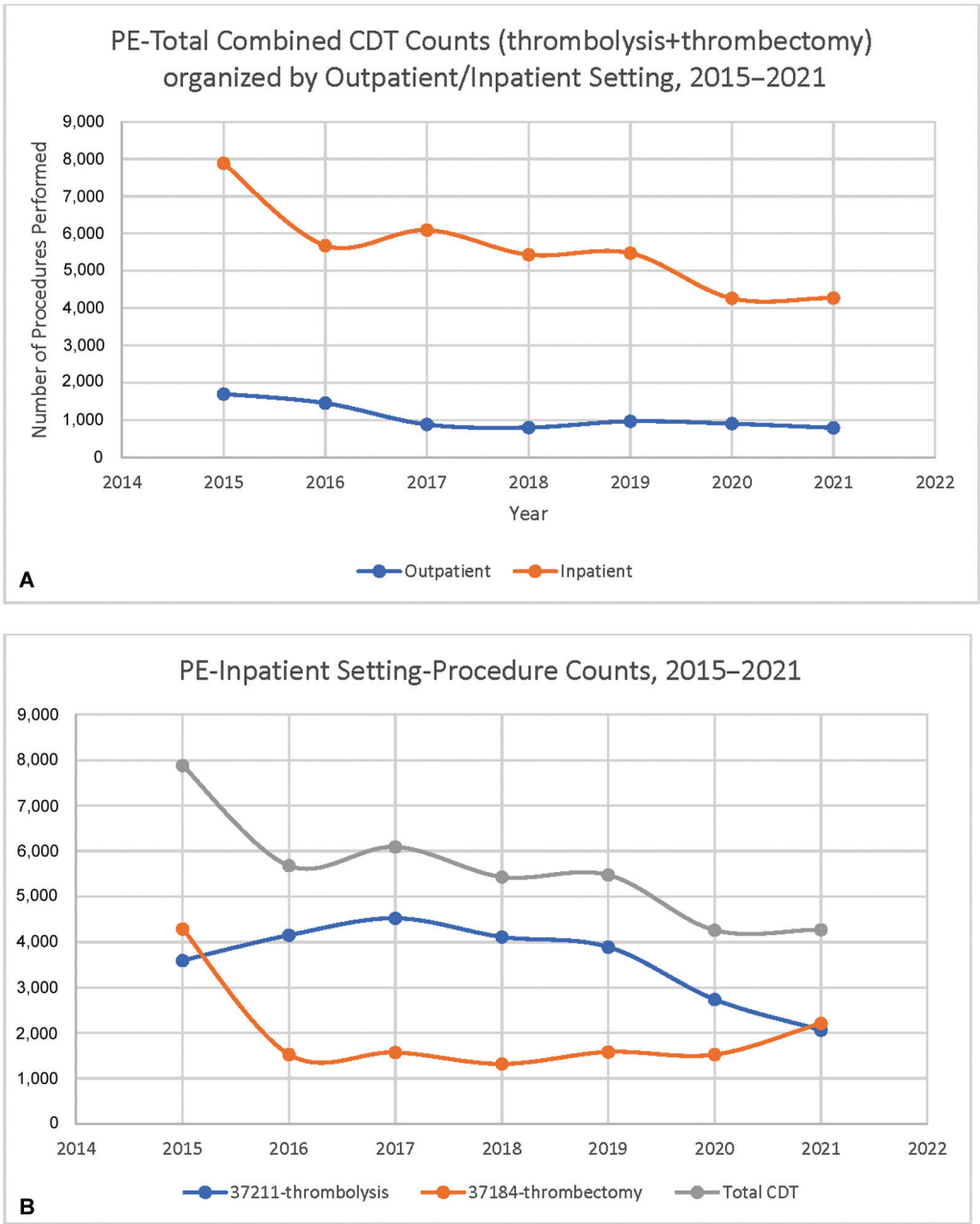


Fig. 6 (A) Combined catheter-directed therapy (CDT) procedure counts for inpatient versus outpatient pulmonary embolism (PE) procedures and (B) inpatient procedures stratified by thrombolysis, thrombectomy, and combined CDT.

Previous publications have investigated usage trends of CDT from 2007 to 2017 for DVT[14] and for PE from 2004 to 2016.[15] Von Ende et al[14] reported a 12-fold increase in DVT CDT from 2007 to 2017, with radiologists performing the bulk of these procedures. Gayou et al[15] reported a 10-fold increase in combined thrombolysis and thrombectomy CDT procedures for PE from 2004 to 2016, with radiologists most frequently (70%) being the providers followed by interventional cardiologists and vascular surgeons. Our analysis in this article corroborates these results over 2015 to 2021, indicating that radiologists still performed the majority of the CDT interventions for DVT, while radiologists and surgeons performed a similar number of CDT procedures for PE. Particular attention is paid to CDT procedures performed based on operator specialty, POS, and ROS in the United States.

Limitations

Limitations of this analysis include use of the Medicare database, which does not include encounters covered by private payers and represents a subset of the U.S. population. The Medicare database also does not provide service counts for hospitals with less than 11 procedures performed each year, so only hospitals with 11+ CDT procedures per year were included in the analysis, excluding procedural trends

noted at smaller-volume centers. Given that most of these procedures are performed at sites with sufficient expertise and procedure volume, the effect of this bias is likely minimal. Although CDT could be differentiated into thrombectomy and thrombolysis, the data do not identify which specific devices may have led to the trend toward increasing thrombectomy procedures. Provider specialty in this database is self-reported, which could lead to inaccuracies in classification. To mitigate this, subspecialties were grouped and analyzed in one of four categories (radiology, surgery, cardiology, and other), similar to prior studies.[14,15]

Conclusion

Nationwide trends from 2015 to 2021 suggest increasing utilization of thrombectomy starting in 2020 when compared to thrombolysis for CDT for both DVT and PE procedures. Medical industry development and promotion of thrombectomy technologies may be a driver of this shift from thrombolysis to thrombectomy.

Data Availability Statement

The datasets generated and/or analyzed during the current study are available in the Data.CMS.gov repository, the Medicare database website Physician/Supplier Procedure Summary - Centers for Medicare & Medicaid Services Data (cms.gov). The authors take complete responsibility for the accuracy of the data analysis.

Authors' Contribution

A.G.T. contributed to the design of the project and data acquisition, drafted and revised the manuscript, and gave final approval of the submitted version. O.S.A. contributed to the conception and design of the project, supervision of data acquisition and data analysis, critical revision of the manuscript, and final approval of the submitted version. Q.Y. and D.K. contributed to critical revision of the manuscript and final approval of the submitted version. M.V.P. contributed to conception and design of the project, supervision of data acquisition and data analysis, critical revision of the manuscript, and final approval of the submitted version.

Conflict of Interest

O.S.A. is a consultant for Angiodynamics, Asahi Medical, Canon Medical, and Bard. He also serves on the advisory board for Medtronic, Boston Scientific, Johnson and Johnson, and Argon. M.V.P. is a consultant for Boston Scientific, Inc, TheraSphere, and Proctor, and serves on the advisory board for Boston Scientific, Inc. None of the other authors has no conflict of interest to declare.

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