ASK THE EXPERTS

Digital Health in DVT: What Would Truly Help Guide Care and Research?

Insights into the digital tools that can help improve patient engagement and advance understanding in deep vein thrombosis care.

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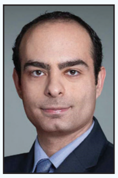

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Deep vein thrombosis (DVT) is a prevalent vascular disorder that poses significant health risks. Traditionally, DVT management has relied on clinical assessments, laboratory tests, and imaging techniques. In addition, clinical trials often face limitations via the need for in-person visits, capturing only fragmented snapshots of a patient's health, which presents logistical and financial barriers and limits data collection.

The advent of digital health technologies (DHTs) presents a transformative opportunity to revolutionize how DVT is diagnosed, monitored, and managed.[1-3] DHTs facilitate continuous remote monitoring of patients' health data during their daily activities, therefore eliminating the limitations of in-person visits and enhancing the quantity and quality of data collected, while enriching these data with a temporal perspective.[4,5] This capability provides richer insights into disease physiology and outcomes through novel measurements and allows for more personalized and proactive interventions.

DHTs encompass a wide array of tools, including electronic health records (EHRs), mobile health applications, wearable devices, and artificial intelligence (AI). Key components include the following:

- Smartwatches and fitness trackers monitor vital signs, activity levels, and changes in body temperature, providing real-time data that may help identify risk factors of DVT.[6]
- Mobile health applications allow patients to track symptoms, increase medication adherence, and encourage lifestyle changes.[7]
- Virtual access to health care providers allows timely care without the need to travel. This is especially beneficial for high-risk individuals who require close monitoring.[8]
- AI-powered ultrasound systems have the potential to enable rapid and accurate clot detection through real-

time image analysis, increasing diagnostic accuracy, reducing misdiagnosis rates, and streamlining the diagnostic process, especially in settings with limited access to specialists. AI algorithms can analyze vast data sets to identify novel risk factors, predict individual patient outcomes, and pave the way for truly personalized DVT care.[2]

Although the potential for DHTs in DVT management is immense, challenges such as data privacy and security must be addressed to ensure these technologies are accessible, secure, and validated for widespread implementation.[9,10] By effectively navigating these challenges, we can unlock a future where DVT is managed more effectively, empowering patients in their care while driving continuous improvement in prevention, diagnosis, and treatment.

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Digital health has immense potential to transform care and research for DVT, particularly by leveraging social media platforms like Facebook, Instagram, and X (formerly known as Twitter). These avenues can be powerful tools for engaging patients, raising awareness, and educating the public about more underrecognized conditions such as postthrombotic syndrome (PTS) and inferior vena cava (IVC) filter complications. By fostering online communities, health care professionals can provide reliable information, counter misinformation, and promote early diagnosis and treatment. Additionally, the integration of large data sets, such as EHRs and claims databases, can significantly enhance our understanding of DVT. These resources allow for the analysis of incidence, prevalence, treatment trends, as well as outcomes on a broad scale, providing valuable insights to guide evidence-based interventions and shape future research priorities. Together, these digital tools offer a dual approach to improving patient engagement and advancing scientific understanding in DVT care.

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AI holds immense potential for transforming the diagnosis, management, and treatment of DVT and addressing critical needs in patient care. Picture an AI system that integrates natural language processing (NLP), medical image interpretation, predictive analytics, and automated disease detection. By continuously monitoring EHRs and imaging databases, this technology could identify patients with a history of DVT who are not on appropriate long-term anticoagulation therapy, flagging them for review. Additionally, it could help pinpoint patients with PTS who have not undergone necessary evaluations, such as reflux studies, or recommended treatments like compression therapy. AI could also identify patients with incidental DVT that may be missed on imaging studies obtained for non-DVT indications. This kind of system could greatly facilitate the creation of large venous thromboembolism registries, generate hypotheses for future clinical and basic science research, and assist in identifying and recruiting patients for clinical trials.

By streamlining these processes, AI could significantly enhance our capacity to provide personalized care. For example, it could alert clinicians to patients who have not been refilling their anticoagulation medication or undergoing necessary tests, such as international normalized ratio monitoring, ensuring they receive timely interventions and support. Additionally, the system could notify clinicians about patients with untreated reflux or iliac venous obstruction based on prior imaging, ensuring they receive appropriate evaluation and management. Beyond improving clinical decision-making, AI could also engage patients with personalized reminders and educational resources delivered through mobile apps. Ultimately, harnessing AI in DVT management has the potential to lead to better outcomes, greater participation in clinical trials, reduced work for providers, more efficient resource utilization, and a more proactive approach to patient care.

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There is no doubt that AI will change how we care for patients with DVT over the coming decade. AI will likely revolutionize patient selection, preprocedural planning, intraprocedural support, and response to therapy prediction, as well as improve provider-patient interactions and patient-centered care. AI will touch every step of the care continuum in DVT care.

Today, there are algorithms already in use for clinical triage to identify patients with iliofemoral DVT who would be good candidates for thrombectomy. These algorithms use NLP or large language models (LLMs) to identify ultrasound reports where DVT patients meet criteria for intervention. Similarly, there are currently products on the market that automatically populate follow-up databases by identifying patients with IVC filters mentioned in any radiology report; the databases include when they are placed and whether the patient meets criteria for removal based on being on anticoagulation (according to EHR data). These data can then be used to contact the patient's responsible clinician to initiate consultation for removal (when warranted) to reduce the risk for long-term complications, including DVT development.

Possible emerging applications of AI in DVT care will allow precision interventions for better patient outcomes. Such applications include procedural planning using computer vision models on preprocedural imaging to identify thrombus chronicity/extent and recommendations on stent sizing (when a stent is needed), among other applications. Intraprocedurally, a few AI labs and start-ups are currently exploring crossmodality image fusion and registration between preprocedural imaging and intraprocedural fluoroscopy to improve intraprocedural guidance. Finally, using multimodal AI models, researchers are developing risk prediction and response-prediction models for patients undergoing different endovascular procedures. Such models (if trained on sufficient data from large registries) will eventually allow us to choose the right patient for the right device/intervention for the most optimal patient outcome.

There is no doubt that LLMs will change how we are practicing medicine over the coming years. A few such examples include LLM-powered chatbots that are currently being tested to communicate with patients and answer their medical questions, with high levels of accuracy. Similarly, such models are currently being used for data summarization and extraction of relevant information from the EHR, improving efficiency for providers. Other non–patient-facing applications include the use of LLMs to support medical billing and insurance appeal processes.

We are entering an exciting new era where AI will improve DVT care for our patients. Although many applications remain in their infancy, I have no doubt that we will soon see AI tools that allow us to select the best procedures and devices for the most optimal outcomes for our patients. ■