

# Evaluating the Effects of an Evidence-Based Hemostasis and Thrombosis Treatment Algorithm on Medical Practitioner and Trainee Clinical Decision-Making

Sven R. Olson, MD<sup>1</sup> Joseph J. Shatzel, MD<sup>1</sup> Derrick Tao, BS<sup>1</sup> Garrett Wasp, MD<sup>2</sup>  
Thomas G. DeLoughery, MD, MACP, FAWM<sup>1</sup>

<sup>1</sup>Division of Hematology-Oncology, Oregon Health and Science University, Knight Cancer Institute, Portland Oregon

<sup>2</sup>Division of Hematology and Oncology, Dartmouth Hitchcock Medical Center, Lebanon, New Hampshire

Address for correspondence Sven R. Olson, MD, Department of Hematology-Oncology, Oregon Health and Science University, 3181 SW Sam Jackson Park Rd, Portland, OR 97239 (e-mail: [olsosv@ohsu.edu](mailto:olsosv@ohsu.edu)).

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Venous thromboembolism (VTE), including deep vein thrombosis and pulmonary embolism, is common, killing up to 100,000 Americans annually.<sup>1</sup> The overall incidence of VTE has increased over the past decade, particularly in those with advanced age.<sup>2</sup> Diagnosis and management of VTE also generate large medical costs, as high as US\$15,000 for a single patient with VTE in the United States and up to US\$33,000 when factoring in subsequent care and sequelae.<sup>3</sup>

Though evidence-based guidelines for diagnosis and treatment of VTE exist, mismanagement is common and can lead to serious negative consequences for patients due to either inadequate or excessive treatment.<sup>4</sup> In a large observational study, nearly half of new VTE cases are not managed based on evidence-based recommendations.<sup>5</sup> Thrombophilia testing is often ordered inappropriately, leading not only to higher costs but also potential harm through unnecessary work-up, treatment, and psychological stress to the patient.<sup>6</sup> Inappropriate VTE treatment lengths are also common, likely contributing not only to increased rates of recurrent thrombosis but also to bleeding complications.<sup>7</sup> Even with this information, describing the true costs of VTE management, both monetary and otherwise, is difficult.

Several factors may be responsible for this discordance between data and practice, including lack of provider awareness of guidelines (cumbersome guideline design), infrequent guideline updates to include the latest high-quality data, low-quality data leading to varying study interpretations, and conflicts between appropriate management and patient wishes. Thrombosis management differs from that of hematological malignancies, as it frequently involves the participation of general practitioners as well as providers in most other fields of medicine, often without direct invol-

vement of a hematologist. Management of hematological malignancies also often benefits from user-friendly and routinely updated evidence-based guidelines, lacking for nonmalignant hematology.<sup>8</sup> A noteworthy measure aimed at reducing some of the more frequent areas of VTE mismanagement was the creation of the American Society of Hematology's (ASH) "Choosing Wisely" guidelines. These include at least five statements pertinent to diagnosis and management of VTE, including recommendations against routine thrombophilia testing, inferior vena cava filter placement, and aggressive use of prothrombin complex concentrates for anticoagulation reversal, among others.<sup>9</sup> While these recommendations, as well as those found in major society guidelines, are high-yielding and backed by high-quality evidence, locating and integrating these recommendations into daily clinical practice remains challenging.

Simplified VTE management guidelines could potentially reduce the burden of this disease on our health-care system. We therefore attempted to address this problem by designing an evidence-based thrombosis and hemostasis treatment algorithm, modeled after the National Comprehensive Cancer Network guidelines for malignancies and designed to be user-friendly and easily accessible.<sup>8</sup> We then prospectively tested this tool's effect on provider and trainee clinical decision-making for VTE, hypothesizing that our tool would lead to improved VTE management decisions.

Using the latest thrombosis guidelines from the American College of Chest Physicians and other major hematological societies, and supplemented by additional high-level data in the fields of thrombosis and hemostasis, we created an electronic diagnostic and treatment algorithm tool for VTE ([www.anticoag.net](http://www.anticoag.net)). We then designed a survey consisting of

several demographic questions as well as 11 clinical questions describing commonly and uncommonly encountered clinical scenarios pertaining to thrombosis and hemostasis, with answers in multiple-choice form. The correct answers were formulated around the most strongly evidence-based data used to design our guidelines. We implemented our algorithms and survey in a prospective, observational, randomized, single-blinded study of health-care providers and medical students from Oregon Health & Science University during July 2016. Study recruitment was arbitrarily capped after this 1-month period. Eligible participants included attending physicians, fellows, medical residents, nurse practitioners (NPs), and physician assistants (PAs) in the fields of internal medicine, family medicine, hematology, and oncology, as well as medical students of all levels of training. Providers working in both inpatient and outpatient settings were included. Participants were recruited through e-mail; at the time of enrollment, participants were randomized to either have access to our algorithmic tool (in digital PDF form) or not; those without access were encouraged to use any other resource they might typically use in their respective clinical settings. The study was single-blind in nature; study coordinators were blinded to participant randomization. Participants were asked to answer the clinical scenarios as well as rate their confidence in each answer. Postassessment feedback was solicited. The location and manner in which participants completed the exercise were not specified. The 11 clinical questions were scored, and an unpaired *t*-test was performed to determine if any significant difference existed in scores between participants with and without the use of our algorithmic tool.

During the study period, 101 individuals participated: 48 medical students, 23 medicine residents, 17 attending physicians, 9 fellows, and 4 NPs/PAs. Across all participants, those with access to the algorithms on average answered 3.84 (34%) more questions correctly (95% confidence interval [CI]: 3.08–4.60;  $p < 0.0001$ ) (►Fig. 1, ►Table 1). The significantly increased number of correct answers was consistent across all subgroups. Participant-reported confidence in their

answers was also significantly higher in those who were randomized to use our algorithm (mean difference 0.95 on a 5-point confidence scale; 95% CI: 0.50–1.39;  $p < 0.0001$ ).

In conclusion, this prospective, observational, randomized, single-blinded study demonstrates that an evidence-based algorithmic tool significantly improved clinical decision-making abilities and confidence of all medical providers in the areas of thrombosis and hemostasis. Specific elements of our tool that likely contribute to its positive effect include easy and rapid access, a commonly used file format (PDF), a familiar, visually appealing, and uncluttered presentation style, and clear citations and links to primary data. Similar tools in the form of online algorithms and smartphone apps are currently available from the American Society of Hematology (ASH “Pocket Guides”), Thrombosis Canada, and the United Kingdom’s Guy’s and St. Thomas NHS Foundation Trust, though we feel that the narrow breadth of topics and lack of robust supporting data in these resources limit their clinical utility.<sup>10–12</sup> To the best of our knowledge, our guidelines are the first to demonstrate a potential for improved clinical outcomes. Our guidelines have since been greatly expanded to include additional primary data and new algorithms for several other areas of thrombosis and hemostasis. These guidelines are now hosted on a custom domain ([www.anticoag.net](http://www.anticoag.net)). Anecdotally, the algorithms on this Web site have seen widespread adoption among practitioners across many subspecialties at our institution. A summary of key points addressed by this correspondence is listed in ►Table 2.

We acknowledge several weaknesses of our study, including single-institution design, small sample and survey size, limited breadth of medical and surgical specialties included, and small number of clinical vignettes in the survey. The sample size was limited due to difficulties in study recruitment. In the interest of simplicity, our guidelines also omit some of the more nuanced data that might be required to manage complex cases. Our algorithms, however, are designed primarily with nonhematology subspecialists, internists, and other primary care providers in mind. We

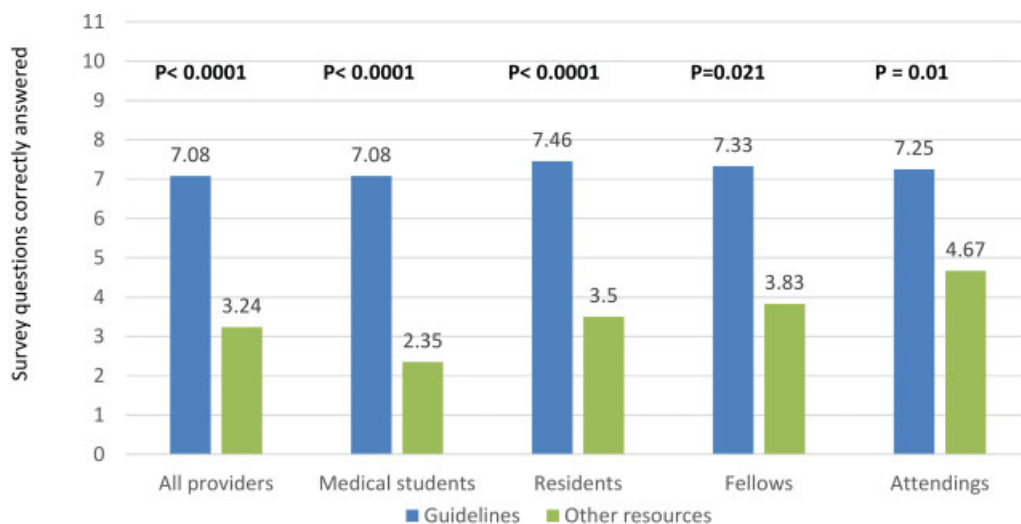


Fig. 1 Survey performance using thrombosis guidelines versus standard resources.

**Table 1** A summary of survey responses

	All participants		Nonmedical students		Medical students		Residents		Fellows		Residents + fellows		Attending physicians		NPs/PAs	
	With (N = 52)	Without (N = 49)	With (N = 27)	Without (N = 26)	With (N = 25)	Without (N = 23)	With (N = 13)	Without (N = 10)	With (N = 3)	Without (N = 6)	With (N = 16)	Without (N = 16)	With (N = 8)	Without (N = 9)	With (N = 3)	Without (N = 1)
Mean score (out of 11)	7.08	3.24	7.07	4.04	7.08	2.35	7.46	3.5	7.33	3.83	7.44	3.63	7.25	4.67	4.67	5
Standard deviation	2.20	1.56	2.16	1.37	2.29	1.27	1.76	1.43	2.08	1.47	1.75	1.41	2.49	1.12	2.52	-
Mean difference of scores	3.84		3.03		4.73		3.96		3.5		3.81		2.58		-0.33	
95% confidence interval	3.08-4.60		2.03-4.03		3.64-5.82		2.54-5.38		0.71-6.29		2.66-4.96		0.63-4.53		-	
p-Value	<0.0001		<0.0001		<0.0001		<0.0001		0.021		<0.0001		0.0131		-	

Abbreviations: NPs, nurse practitioners; PAs, physician assistants.

**Table 2** A summary of key points addressed by this correspondence

VTE is often mismanaged despite evidence-based guidelines
We implemented a streamlined algorithm for VTE treatment in a prospective, single-center study
Our algorithm led to statistically significant improvement in VTE management in all training levels
These algorithms will be expanded to include additional thrombosis and hemostasis topics

Abbreviation: VTE, venous thromboembolism.

aim to expand the content of our guidelines and test them prospectively in other medical centers and in a larger variety of controlled clinical settings to further explore its impact on medical decision-making. This research would provide a valuable feedback to help modify the tool to include the most relevant information. Should this model prove effective, it could be appropriated for other areas of nonmalignant hematology.

**Compliance with Ethical Standards**

This article does not contain any studies with human participants or animals performed by any of the authors.

**Authorship Contributions**

S.R. Olson, MD, contributed to algorithm design and manuscript drafting. J.J. Shatzel, MD, contributed to project conception and design, algorithm design, and manuscript drafting. D. Tao contributed to algorithm design. G. Wasp, MD, contributed to the data provision and manuscript drafting. T.G. DeLoughery, MD, MACP, FAWM, contributed to project conception/design and critical edits.

**Conflicts of Interest**

The authors have no conflicts of interest to disclose.

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