Automated dynamic sepsis surveillance with routine data: opportunities and challenges

Holger A. Lindner[1], Manfred Thiel[1], Verena Schneider-Lindner[1,2]

[1]Department of Anaesthesiology and Surgical Intensive Care Medicine, Medical Faculty Mannheim, Heidelberg University, Heidelberg, Germany; [2]Department of Community Health Sciences, University of Manitoba, Winnipeg, Canada

Correspondence to: Verena Schneider-Lindner. Department of Anaesthesiology and Surgical Intensive Care Medicine, Theodor-Kutzer-Ufer 1-3, 68167 Mannheim, Germany. Email: verena.schneider-lindner@medma.uni-heidelberg.de.

Provenance: This is a Guest Correspondence commissioned by Section Editor Zhi Mao, MD (Department of Critical Care Medicine, Chinese People's Liberation Army General Hospital, Beijing, China).

Response to: Nandi U, Puskarich MA, Jones AE. Big data to the rescue of systemic inflammatory response syndrome: is electronic data mining the way of the future? Ann Transl Med 2016;4:465.

Namas RA, Vodovotz Y. From static to dynamic: a sepsis-specific dynamic model from clinical criteria in polytrauma patients. Ann Transl Med 2016;4:492.

Submitted Dec 19, 2016. Accepted for publication Dec 25, 2016.
doi: 10.21037/atm.2017.01.29
View this article at: http://dx.doi.org/10.21037/atm.2017.01.29

Clinicians face an ever-increasing workload due to rising medical complexity of their patients, particularly in the intensive care unit (ICU). Difficulty in keeping abreast of the current clinical situation of critically ill patients with strongly fluctuating health state is augmented by abundance of information from vital signs, laboratory tests, and imaging studies. Rising pressure also comes from cost constraints and performance measurement. Advances in health information technology drive standards and demands, in turn, adding to the pressure. At the same time, mining of medical information in critical care still holds great potential in supporting clinical decision making.

Sepsis is the most common cause of death in non-coronary ICUs, its incidence increasing. Reliable sepsis diagnosis is literally vital not only for individual patients but also for public health by ensuring preservation of future treatment effectiveness through prevention of antibacterial resistance development. Current sepsis detection based on biomarkers and clinician judgment, however, lacks specificity and therefore represents a major clinical challenge.

Despite investigation of hosts of candidate biomarkers, clinical sepsis diagnosis still relies heavily on vital signs and routine laboratory parameters. As part of standard monitoring, these are easy to obtain and interpret by clinicians of all disciplines. Collection of such data is largely noninvasive and causes no extra burden on patients, physicians (no need for ordering and reviewing extra tests) or the system (costs). In addition, electronic storage in principle allows for quick data access.

The systemic inflammatory response syndrome (SIRS) and SIRS criteria have been the cornerstones of clinical sepsis diagnosis and sepsis research (1) since their initial definition in 1992 (2) and subsequent slight modification in 2001 (3). We therefore sought a reflection of SIRS in the electronic medical record (EMR) of our surgical ICU (4).

In contrast to spot check evaluations at the bedside, retrospective determination of SIRS in our data required further definitions than the existing criteria, because the necessary parameters are recorded neither concomitantly nor continuously. In establishing durations of validity of parameters underlying the SIRS criteria for our computerized SIRS algorithm, we realized that it was possible to expand the current static approach to systemic inflammation towards a dynamic conceptualization. We hypothesized that a thus enhanced description of patient status is potentially superior to current diagnostic measures of sepsis. In our initial cross-sectional evaluation of the SIRS algorithm in all admissions of our ICU we could replicate established SIRS prevalence of ICUs shown in a previous

investigation supporting the validity of our approach. We concur with Nandi, Puskarich and Jones (5) that one drawback of our study that generally burdens sepsis research is the lack of a gold standard for sepsis diagnosis. Testing a diagnostic strategy against clinical practice, which is itself largely based on the same parameters used by this strategy, may result in finding overly optimistic properties for it. In our case SIRS is based on routine parameters commonly used in clinical sepsis diagnosis, hence, evaluation of SIRS for sepsis diagnosis is prone to this problem. One important, albeit not the only, feature of sepsis patients, which should ideally be present in each case and is independent of SIRS parameters, is microbiological confirmation of the infection. In our study, this had been possible in 69 out of 85 cases (81%), and the infectious focus had been identified in all but two patients. This supports a comparatively high confidence in the validity of sepsis diagnoses in our physician validated polytrauma cohort.

We evaluated our SIRS algorithm and SIRS descriptors in polytrauma patients who suffered a defined hit and were at both high injury-related SIRS and sepsis risk. Two aspects are noteworthy here: (I) during the study period, our surgical ICU had many admissions for post-operative surveillance and neurosurgical patients as well as trauma admissions with low injury severity not qualifying as polytrauma. Relative to the total number of admissions, the cohort of definitive polytrauma patients may, therefore, appear small; (II) for our diagnostic analysis we selected controls with risk set sampling which means controls were non-cases and included cases-to-be. Cases and controls were automatically matched for length of stay which in polytrauma patients closely overlaps with the time since injury. This approach takes into account that physicians have to distinguish current non-sepsis from current sepsis patients without knowing which of the sepsis-free patients will later turn septic. Importantly, systematic exclusion of sepsis-free time in the, presumably, overall more severely ill patient group from the comparison may also illegitimately amplify group contrasts.

The change in SIRS preceding sepsis may reflect actual onset of infection or represent a general sign of failing defenses against infection which itself takes root only shortly before it is recognized as sepsis. It is therefore important to acknowledge that, as pointed out by Namas and Vodovotz (6), our study does not provide detailed mechanistic insight. It may, however, provide further leverage for investigation of mechanisms underlying the observed changes in vital signs and leukocyte proliferation.

The proposed concept of using quasi time-dependent descriptors of SIRS for sepsis detection requires further evaluation in other patient groups and additional data sources. Potential benefits may vary for different patient groups, e.g., elderly, for whom specific rules may have to be derived. However, the revised sepsis definition (sepsis-3) no longer includes SIRS, which is now assigned a possible role in diagnosing infection (7). This, in our view, shifts clinical and research activity away from early detection of sepsis.

Instead, encouraged by our results, we advocate focusing on further evaluation of the diagnostic potential of routine data for SIRS-based sepsis detection. This is not limited to the SIRS criteria but includes patient characteristics and time-dependent information from clinical parameters such as laboratory data, physiological parameters, and interventions modifying sepsis risk. Indeed we anticipate that the classical SIRS criteria will coalesce in a future, far more complex algorithm, allowing a personalized diagnostic approach. In reaching this aim we will have to balance technical possibilities and simplicity. In our view the latter is crucial for acceptance by clinicians. We will therefore continue algorithm development based on our intuitive SIRS descriptors and increase complexity only stepwise. The final product could be a learning electronic surveillance and clinical decision support system, assisting clinicians in providing better patient care. Clinical success will eventually depend on demonstration of improved patient-relevant outcomes including mortality. Moreover, implementation will only succeed if system output is adjusted to local clinical practice and enables improved clinical work flow and thus positively impacts on workload. This represents a significant, final part of translation into practice.

In our study we have presented an algorithm that may represent a step towards a potential clinical decision support system for sepsis diagnosis for clinicians facing the dilemma of either overlooking or overtreating sepsis. We expect a future algorithm for early sepsis recognition to be based on more elaborate dynamic SIRS criteria likely combined with other clinical variables and biomarkers.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

References

1. Sprung CL, Schein RM, Balk RA. To SIRS With Love-An Open Letter. Crit Care Med 2016. [Epub ahead of print].
2. Bone RC, Balk RA, Cerra FB, et al. Definitions for sepsis and organ failure and guidelines for the use of innovative therapies in sepsis. The ACCP/SCCM Consensus Conference Committee. American College of Chest Physicians/Society of Critical Care Medicine. Chest 1992;101:1644-55.
3. Levy MM, Fink MP, Marshall JC, et al. 2001 SCCM/ESICM/ACCP/ATS/SIS International Sepsis Definitions Conference. Intensive Care Med 2003;29:530-8.
4. Lindner HA, Balaban Ü, Sturm T, et al. An Algorithm for Systemic Inflammatory Response Syndrome Criteria-Based Prediction of Sepsis in a Polytrauma Cohort. Crit Care Med 2016;44:2199-207.
5. Nandi U, Puskarich MA, Jones AE. Big data to the rescue of systemic inflammatory response syndrome: is electronic data mining the way of the future? Ann Transl Med 2016;4:465.
6. Namas RA, Vodovotz Y. From static to dynamic: a sepsis-specific dynamic model from clinical criteria in polytrauma patients. Ann Transl Med 2016;4:492.
7. Singer M, Deutschman CS, Seymour CW, et al. The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3). JAMA 2016;315:801-10.

Cite this article as: Lindner HA, Thiel M, Schneider-Lindner V. Automated dynamic sepsis surveillance with routine data: opportunities and challenges. Ann Transl Med 2017;5(3):66. doi: 10.21037/atm.2017.01.29