



PEGALUS and other patient predictive scores of COVID-19 patients

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We physicians are taught to look for patterns in our patients. Mnemonics and other memory aids make it easier. Even more effective are clinical scores, combining data like patient demographics, medical, surgical and family histories, signs, symptoms, medication use, physical findings, and data from laboratory and imaging testing into a single score, ideally one that is simple to calculate and use, and hopefully has some useful predictive power. Of course, such scores work best when they have a memorable name! From the first minute of a patient's life, for example, we have his or her Apgar score [1], and it continues from there. Clinical scoring systems can provide valuable guidance for resource use such as hospitalization, prophylaxis, treatment, and additional testing, and for prognosis. Health service researchers and biostatisticians have helped create robust methods for derivation and validation of such clinical scoring systems.

COVID-19 has caused the first pandemic in the age of the electronic medical record (EMR). Huge amounts of data of all sorts have become readily available to help us understand the effects and predict the course of COVID-19 infection. Researchers are, naturally, looking for ways to turn potentially complex statistical models into clinical scoring systems that are at once powerful yet simple enough to allow them to be quickly and readily used in a busy clinical environment, such as an Emergency Department, perhaps while donning and doffing PPE and also assessing a variety of other patients. Many examples have already been developed in clinical centers all around the world, including: the “EXAM” score to predict future oxygen requirements of COVID-19 patients [2]; the “COVID-GRAM” score

to predict development of critical illness [3]; the “JRSS” score to risk-stratify Emergency Department patients [4]; the “COVID-IRS” score to predict risk of mechanical ventilation [5]; and the “PAIN” [6], “CANPT” [7], and an Iranian score to predict severe COVID-19 illness [8], among many others. Generalizability, both geographically and over time, is an additional challenge; Wyants et al. reported that COVID-19 prediction models “are at high risk of bias, raising concern that their predictions could be unreliable when applied in daily practice.” [9]. Soto-Mota et al. have noted that the predictive power of COVID-19 mortality scores tend to decay over time, sometimes to the point where they are no better than clinical gestalt [10]. Of course, any scoring system for COVID-19 will be most accurately predictive in the context of the clinical situation when it was derived, potentially requiring revision in response to such changes as new immunization technologies and strategies, and to evolving COVID-19 virus strains.

The most recent foray into the realm of COVID-19 scoring systems is the “PEGALUS” score of Borio et al. [11]. Developed in Italy, this scoring system is intended to predict death and/or orotracheal intubation within 30 days among Emergency Department patients, based on the study of 230 COVID-19-positive patients, 21.5% of whom went on to either or both of these endpoints. Although not specifically stated as an exclusion, the study does not appear to have included children. The scoring system includes points for: age 65 or more (yes/no); $PO_2/Fi O_2$ ratio (in one of four groups); $PCO_2 < 35$ mmHg (yes/no); duration of symptoms < 7 days (yes/no); and visual Lung Ultrasound Score (LUSS) pattern (in one of four groups). The LUSS pattern component is based on bedside point of care ultrasound (POCUS) in the Emergency Department, and is a refinement of several earlier LUSS studies [12–15]. It is itself a novel scoring system, using protocolized POCUS scanning of twelve lung regions, with a score of 0–3 points being assigned to each region, based on severity of disease. Each

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region's points are then totaled, and patients with point totals within specified ranges are allocated to LUSS pattern 1, 2, 3, or 4; patterns are then converted to points on the PEGALUS score. Total PEGALUS scores range from 0 to a possible maximum of 21.5, with worse scores corresponding to worse prognoses. PEGALUS scores < 7 were strongly associated with good outcomes, while those > 11 were strongly associated with adverse outcomes. Thus, PEGALUS identified both high-risk and low-risk patient populations, as well as a mid-range group. The authors suggest that patients with PEGALUS scores < 7 may be safely managed at home, those with scores of 7–11 undergo additional evaluation, and those with scores > 11 be rapidly hospitalized, perhaps in an intensive care unit setting.

The PEGALUS scoring system has pros and cons. It uses data that are readily obtained in an Emergency Department setting: demographics, duration of symptoms, COVID-19 testing, blood gas results, and findings from POCUS, the use of which is rapidly becoming common in the Emergency Department setting. The area under the curve (AOC) for the Receiver-Operator Characteristic (ROC) curve, for the PEGALUS score was strong, at 0.866. Readers practicing in Italy may be especially interested in using a score derived in the same country. And, of course, the very name PEGALUS is inspiring! However, the process of using POCUS to determine LUSS for each of twelve regions, totaling the scores to convert them into a LUSS pattern group, then assigning PEGALUS points based on that pattern group, is somewhat cumbersome. While a patient's COVID-19 vaccination status may alter the importance of clinic-demographic variables included in PEGALUS, vaccination history is not considered in the scoring system. Although the system has good predictive power as retrospectively derived, specifically for adult patients, there has not been a corresponding prospective or validation study in another patient population to test its generalizability.

The intersection of the age of the EMR with the COVID-19 pandemic has given us unprecedented opportunities to rapidly develop prediction models specific for infection by this single virus. The PEGALUS score may represent a genuine advance in Emergency Department-based care of the adult COVID-19 patient. Further, as the authors point out, the PEGALUS score may also work well in understanding other forms of interstitial pneumonia [11]. The PEGALUS score must, however, undergo additional validation study before being widely adopted. As COVID-19 infection and its management evolve with changing immunization science, changing predominance of viral strains, improved viral detection and supportive care methods, and changing societal factors, we will need to continually re-test and refine this and all other COVID-19-specific predictive patient scoring methods. Perhaps there will be a PEGALUS-2 score in the future! What we learn through development of clinical

scoring systems will certainly inform us about creating and maintaining patient predictive scores during the data-rich, high stakes pandemics of the future.

Declarations

Conflict of interest The author declares that he has no conflict of interest.

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