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EDITORIAL (BY INVITATION)

The "weekend effect" and outcomes after clipping of ruptured intracranial aneurysms—general healthcare metrics and trained vascular neurosurgeons

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The 2001 landmark *New England Journal of Medicine* paper by Bell and Redelmeier [2] managed to express in numbers a generations-old belief: patients admitted in the weekend to the hospital are at higher odds of death than those admitted during weekdays. On the one hand, weekend understaffing and reduced senior consultant oversight and input are worrisome to both junior doctors as well as hospital administrators [6]. On the other hand, patients admitted in the weekend are expected to be, on average, sicker than those admitted during weekdays. In this latter case, the "weekend effect" would be nothing more than a difference in mortality induced by data laden with confounding by indication. Nevertheless, in the past two decades, numerous reports on this topic have been published, some using state-of-the-art statistical methods and some databases [5] designed with this purpose in mind [4, 6, 10, 14]. While some papers conclude that the impact of the weekend effect on patient care has been declining recently [10], others still find it prevalent in various healthcare systems [14]. Much like other such observations and beliefs, which stem from the organization and logistics of healthcare systems, the issue does not lend itself to analysis using a randomized design. This invariably introduces various limitations in these studies, despite the large number of patients included. A potential solution to overcome some of the limitations would be to compare results using a quasi-experimental design in diverse healthcare systems, with their own different weekend staffing levels.

For patients presenting with aneurysmal subarachnoid hemorrhage (aSAH), the reports are conflicting. A 2009 analysis concluded that weekend admissions were not associated with a higher risk of mortality [3]. More recent reports, however, have called this into question [8, 11]. The inherent limitations of these individual studies prevent us from drawing any definitive conclusions. One issue that confounds the analyses is the difficulty in isolating the effect of the "day of admission" on the ultimate outcome. A patient with aSAH might spend 3 or 4 weeks—and weekends—in an ICU, during which time various outcome-influencing events may occur. If there is indeed a "weekend effect" in aSAH, various factors could lie at the heart of the issue: availability of vascular neurosurgeons and/or interventional specialists; treatment preference (e.g., complex aneurysms which would be better treated by microsurgical reconstructions might be deferred to endovascular treatment with suboptimal results); less experienced junior staff that might not get help from a senior colleague as easily, etc.

In this issue of *Acta Neurochirurgica*, Goertz et al. [7] present a retrospective single-center analysis of 157 aSAH patients between 2010 and 2019 who underwent microsurgical clipping during (1) regular working hours or (2) during on-call hours, either at daytime or nighttime. The premise of the study was the hypothesis that clipping during nighttime might be associated with worse surgical performance. This phenomenon might stem from the reduction of cognitive abilities due to the human circadian rhythm, and the restricted technical and personnel resources at night. Their results are in a certain sense reassuring: although microsurgical clipping at nighttime carried higher odds of unfavorable outcome at discharge, this difference was not statistically significant neither on short-term follow-up nor after confounder adjustment. The other outcome parameters, e.g., operation time, intraoperative rupture rate, treatment-related complications, vasospasm and

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angiographic results, and in-hospital mortality, did not differ between the two groups. A total of 7 vascular neurosurgeons performed surgeries during the study period. Of these, 3 performed the most on-call surgeries (> 75%) and 2 only performed elective surgeries. It is unclear if any overlap was present, i.e., whether 2 or more vascular neurosurgeons operated together. It is also unclear what the pre-study caseload was for each individual neurosurgeon in order to gauge experience. The complete occlusion rates hovered around 70%. Only one-third of those admitted during on-call hours were actually operated at night. It is likely these were patients with intracerebral hematomas, but this information is also unknown.

An issue which ties into the "weekend effect" and that will likely confound results in most studies is the issue of timing of intervention [1]. While treating ruptured aneurysms within 24 h has become the norm in most neurovascular centers, the jury is still out on whether "ultra-early" treatment is necessary [9, 12], i.e., treating all ruptured aneurysms immediately after admission in an effort to minimize the rate of rebleeding. However, ultra-early treatment refers not only to the microsurgical clipping, but to the entire system built around the admission of aSAH patients. This includes the clinical suspicion of first responders, the ability to quickly transfer such patients to an expertise neurovascular center, and the ability of neuro-interventionists and vascular neurosurgeons (or hybrid neurosurgeons) to swiftly decide the best course of action for the patient and carry this out. The logistics circuit required to successfully deliver a patient with aSAH safely to a specialized neuro-ICU (with a secured aneurysm), however, is much more complicated [13].

The data by Goertz et al. [7] show that an age-old belief turned healthcare-metric likely does not apply to the performance of trained vascular neurosurgeons, which should make us rejoice. As the authors themselves remark in the study, there likely is a weekend effect on ischemic stroke patients in non-stroke centers, but comprehensive stroke centers following standardized treatment protocols are not affected by it. The authors' results may be seen as a proxy for the same phenomenon in aSAH.

However, we are not there yet. Whether there is a weekend effect that affects the complex chain of care of aSAH patients cannot be ruled out. And if an "ultra-early" treatment policy were exercised, would the weekend effect play a role? Can contemporary healthcare systems deliver the required dedication to keep a complex team ready and able to handle aSAH 24/7 on a moment's notice? Or will burn-out and irregular hours result in nefarious effects which negate the positive effects of the extra rebleeds prevented? aSAH remains a complex and challenging disease, which stretches far beyond merely securing the aneurysm. Trials such as ISAT show that the most important factor for outcome in aSAH patients is the disease itself [1], not so much the initial choice or treatment (coil or clip). In future studies, the focus should be on comparing different systems of care in order to identify the magnitude of the "weekend effect" and ways to mitigate it.

Compliance with ethical standards This article does not contain any studies with human participants performed by any of the authors.

Conflict of interest The authors declare that they have no conflict of interest.

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