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outcomes. Interestingly, RCTs targeting intraoperative BP thresholds have found no differences in 30 day<sup>9</sup> or 90 day mortality.<sup>10</sup>

In summary, Wesselink and colleagues<sup>2</sup> have presented a robust, well-organised systematic review of the disparate studies on the association between intraoperative hypotension and adverse postoperative outcomes. Because of large variations in study populations, definitions of hypotension, surgical procedures, outcome measurements, and analytic methodology, we are still unable to definitively point to intraoperative hypotension as the culprit of adverse outcomes. Nonetheless, the review reveals multiple avenues for future research that may bring us closer to making sense of hypotension. We may not know how to define hypotension, let us hope we recognise it when we see it.

### Authors' contributions

Discussed an overview, contents, and the proposed narrative before composing the manuscript: J.X.C.K., W.S.B.

Wrote the first draft: J.X.C.K.

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### Declaration of interest

The authors declare that they have no conflicts of interest.

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## Counting the cost of cancelled surgery: a system wide approach is needed

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Cancellation on the day of surgery is a major issue in the UK NHS and other healthcare systems. A recent prospective epidemiological study over a 1 week period in NHS hospitals suggested a cancellation rate of between 10% and 14% and that only one-third of these were because of clinical reasons. This editorial explores the implications of the findings of this study and how clinicians, managers, and healthcare commissioners might reduce this problem.

As the UK NHS entered its 70th year, figures from the first quarter of 2018 showed that 25 475 operations were cancelled in NHS England on the day of surgery. This is the highest quarterly figure recorded since records began in 1994. At the start of this year, NHS England recommended that all hospitals cancel elective surgery for the month of January. As a consequence, government targets to treat 92% of patients within 18 weeks were missed for the second year running.<sup>1</sup> Winter bed pressures and a failure to discharge patients awaiting social care packages from acute beds are routinely blamed for cancelled surgery. Recent data from the Royal College of Surgeons of England and The King's Fund suggest that not only is this problem increasing year on year,<sup>1</sup> but that increased hospital occupancy extends all year round as hospitals attempt to reschedule cancelled admissions.<sup>2</sup>

Bed pressures, particularly over winter months, are not the sole reason for cancelled surgery. Other issues can be implicated, including failure of adequate preoperative assessment, staff shortages, access to operating theatres, equipment shortages, and critical care capacity. Cancellation on the day of surgery is costly for patients and healthcare providers. In addition, it can have profound consequences on patients' health and experience, extending their period of pain or debilitation and even worsening long-term outcomes in surgery for cancer or cardiovascular disease. Estimates quantify cancelled surgery in the UK at 1.3% of all hospital admissions. The cost in lost operating theatre time is as high as £400 million per year. Hence, detailed information on the reasons for cancelled surgery and strategies to reduce this is of great interest to healthcare providers, clinicians, and the public.

In this issue of the *British Journal of Anaesthesia*, Wong and colleagues<sup>3</sup> present a prospective observational study exploring the reasons for cancellation on the day of surgery in 245 NHS hospitals across the UK. Theirs was a planned sub-study of the Second Sprint National Anaesthesia Project: EPIdemiology of Critical Care provision after Surgery Study (SNAP-2: EPICCS). This prospective, observational, cross-sectional study into critical care provision for adult surgery was conducted over one week in 2017. Of 15 000 patient episodes, 10% of patients enrolled had been previously cancelled for the same procedure. Moreover, 13.9% of patients attending for inpatient surgery on the week of the study had their surgery postponed. The investigators used statistical modelling to identify factors associated with postponement of surgery at patient and hospital levels. Although non-clinical factors such as hospital bed capacity and operating theatre capacity were highlighted, clinical reasons were responsible for 33% of historical cancellations and 28% of contemporaneous cancellations. Patients who required postoperative critical care were at higher risk of being cancelled, while those undergoing obstetric surgery, emergency surgery, or cancer surgery were at reduced risk. Hospital factors associated with a risk of cancellation were the presence of an emergency department and enhanced ward care areas.

This study increases our understanding of what seems to be an intractable problem in NHS institutions and beyond. This was a large study involving more than 90% of UK

hospitals. However, in common with many epidemiological studies, there are limitations. The study period was a single week in March, and thus may not be representative of conditions throughout the year, particularly in winter months when hospital occupancy and cancellation rates are known to be higher.<sup>2</sup> There was limited granularity in the clinical reasons for cancellation (e.g. was it because of poor preparation or unexpected deterioration in patient health). In 14% of historical cancellations and 57% of contemporaneous cancellations, no reason was identified at all. Finally, the UK has a unique healthcare structure and the results of this study may not be applicable to an international audience. Despite these, what relevant information from this study can be learned and applied by those delivering surgical care to minimise the risk of cancellation?

Provision of acute hospital beds clearly remains an issue, particularly at times of peak demand. Tied in with this issue is access to long-term care beds, rehabilitation beds, and availability of home care support packages, preventing discharge. This is also a major issue in other healthcare systems including North America; for example in Ontario, hospital overcrowding and occupancy of more than 100% has also become the norm.<sup>4</sup> In this study, the presence of an emergency department was strongly associated with risk of cancellation. Unsurprisingly, the co-provision of acute and emergency services in NHS hospitals may result in emergency admissions being prioritised over admission for elective procedures, thus resulting in cancelled surgery. This may be compounded in the presence of competing government targets, for example simultaneous delivery of the emergency department 4-h wait target and the 18-week maximum waiting time for elective treatment. This and the time-critical nature of cancer surgery may explain the finding that cancer surgery was less prone to cancellation. In the UK, these patients are prioritised by clinicians and hospital managers, and are thus less likely to be postponed. Data from Canada suggest that this approach does not impact adversely on other non-prioritised surgery (e.g. elective major joint replacement).<sup>5</sup>

To apply the findings of this study to a broader setting than the UK, one must first consider the funding model for each system, for example whether institutions receive a fixed amount of money to deliver surgical care to a population or where funding is based on activity. In the latter, institutions would be incentivised to hire more staff and open more beds to accommodate additional activity at times of peak demand. Reducing or even stopping elective operating completely in winter months is unlikely to be a long-term solution to this problem, as many hospitals report capacity issues beyond the traditional winter months and the postponed surgery must be accommodated at another time in the year.<sup>2</sup> There are advantages to creating virtually or physically separate elective operating centres, or at least ensuring ring-fenced beds within an acute hospital. This approach can not only reduce cancellations, but also the length of stay and postoperative complications.<sup>6</sup> This may also prove a strong argument for the creation of cancer treatment centres, where prompt access to surgical treatment may be only one of several advantages, for example more seamless preparation for and delivery of preoperative and postoperative chemotherapy or radiotherapy.

Access to operating theatres is another area where improvements might result in reduced rates of cancellation. The investigators found that obstetric and emergency surgery were less prone to cancellation. This might be explained by appropriate clinical prioritisation of these patients. However,

obstetric and emergency cases also tend to have dedicated operating theatres that can improve throughput and reduce cancellation. Interestingly, even during the severe acute respiratory syndrome (SARS) crisis in 2003, emergency care in Toronto hospitals was largely preserved, while elective cases were reduced, consistent with the vulnerability of elective surgery to competing hospital pressures.<sup>7</sup> Ensuring that there is adequate dedicated operating theatre capacity for emergency general surgery and orthopaedic trauma to minimise delay in treatment is strongly linked with outcome, and might also minimise cancellation and delay for other patients undergoing elective surgery.

Inadequate critical care provision has long been cited as a reason for postponed surgery and inferior patient outcomes after high-risk surgery. In this study, the requirement for postoperative critical care was associated with an increased risk of cancellation. Although admission to critical care is recommended for many types of high-risk surgery, data from epidemiological studies do not support routine admission to critical care after elective surgery,<sup>8,9</sup> except in the highest risk groups.<sup>10</sup> Although the UK is thought to have fewer critical care beds per capita than other developed countries, international definitions of critical care beds are not standardised. Research within the UK suggests that per capita critical care provision is not linked with improved outcome.<sup>11</sup> Patients selected for direct postoperative admission to a critical care area are likely to have more co-morbidities<sup>10</sup> and this may also explain the increased risk of cancellation seen in this study. It is also known that there is a wide variation in ICU admission practice after surgery, much of which is at hospital level. Even without clear evidence that critical care improves postoperative outcomes, there is a need to better standardise criteria for postoperative critical care admission across hospitals.<sup>12</sup> Enhanced care wards have been suggested as an alternative to critical care for patients undergoing major surgery, however, this study did not suggest that their presence reduced the rate of cancellation.

Although it is tempting to attribute many of the reasons for cancelled surgery to hospital factors, government policy, or healthcare delivery, we must acknowledge the finding that up to a third of cancellations in this study were for clinical reasons.<sup>3</sup> While we do not know if this was because of unexpected clinical deterioration, intercurrent illness, or inadequate preoperative preparation, we must consider the possibility that better preoperative assessment, risk stratification, and optimisation of pre-existing medical conditions might reduce the risk of cancellation on the day of surgery. With admission on the day of surgery now the norm, there is limited time for additional investigations or treatments for unexpected issues that arise on the day of surgery. Anaesthesia-led preoperative evaluation clinics have been shown to significantly reduce rates of last minute cancellations.<sup>13</sup> These are clinics that in some way assess—in person or by phone—almost all elective surgical cases. Such clinics have a broader role than specialised preoperative cardiopulmonary exercise testing clinics. Comprehensive preoperative assessment, with involvement of other specialties and assessment of functional capacity, is critical to minimising cancellations on the day of surgery. If such clinics help reduce costly last-minute cancellations, hospitals may be incentivised to fund them. This is recognised as a goal of perioperative medicine delivery and the role of interventions to improve physical, nutritional, and psychological condition before surgery has

been identified as an area in which more research is required.<sup>14</sup>

In conclusion, this study highlights the scale of the problem of surgical cancellation along with its implications for patients and optimal use of resources. It also offers us insights into associations with clinical and healthcare delivery factors. The problem of cancelled surgery is complex, and the results of this study underscore the need for clinicians and healthcare providers to work together to develop systems that ensure that there is adequate bed and operating theatre capacity for elective surgery. The 'systems' here must extend beyond the acute care hospital to encompass long-term care beds and home nursing care provision. They must also encompass optimal patient preparation and accurate assessment of risk so that costly and finite resources, such as critical care and operating theatre capacity, can be utilised effectively.

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## Declaration of interest

The authors declare that they have no conflicts of interest.

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## Sugammadex: the sting in the tail?

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Sugammadex, a modified cyclodextrin molecule, encapsulates rocuronium and other aminosteroid neuromuscular blocking agents (NMBAs) to provide rapid and reliable reversal of neuromuscular block. In comparison to the standard reversal agent, neostigmine, the quality and speed of reversal are impressive, reversing moderate block around 17 times faster<sup>1</sup> and with fewer episodes of partial reversal in recovery.<sup>2,3</sup> In addition, it can provide reversal from deep blockade,<sup>3,4</sup> a feature not possible with neostigmine. Arguably, sugammadex is the ideal reversal agent whenever an aminosteroid NMBA is used, as it can potentially speed recovery and improve turnaround time in surgical lists.<sup>5</sup> Sugammadex has also been proposed as an agent to treat rocuronium-induced anaphylaxis, with isolated case reports in the literature suggesting an almost immediate reversal of the anaphylaxis cascade when sugammadex was administered.<sup>6,7</sup>

The main barrier to the use of sugammadex, in the majority of countries, is cost. It is up to 20 times more expensive than neostigmine at a dose of 2–4 mg kg<sup>-1</sup> (for reversal of moderate block), and clearly even more expensive with the 16 mg kg<sup>-1</sup> dose (for reversal of profound block). In Japan, however, the national healthcare insurance system subsidises patient care, and the cost of drugs seems only a minor consideration for

anaesthetists. Here, sugammadex is used routinely, and an estimated 10% of the population received sugammadex during an 8 yr period from 2010 to 2018.<sup>8</sup>

Another concern around the use of sugammadex is the risk of hypersensitivity. Indeed, sugammadex was only approved for use in the United States in 2015 (compared with 2008 in Europe and Australia) because of concerns about hypersensitivity. It is ironic that, as sugammadex was approved by the US Food and Drug Administration (FDA), the body of evidence of hypersensitivity to the drug in clinical settings seems to be strengthening: in Japan, sugammadex is now the leading cause of perioperative anaphylaxis.<sup>8</sup>

Two papers in this issue of the *British Journal of Anaesthesia* report investigations of sugammadex hypersensitivity.<sup>9,10</sup> These clinical trials undertaken before FDA approval and funded by the manufacturer of sugammadex were presumably done with a view to allaying concerns about the incidence of hypersensitivity, whereas they may have had the opposite effect. Both trials involved giving sugammadex at doses of either 4 or 16 mg kg<sup>-1</sup>, or placebo, repeated twice at weekly intervals, to healthy non-anaesthetised subjects. The aim was to establish the rate of hypersensitivity and to determine whether hypersensitivity became more likely after repeated administrations. They also sought to determine the underlying mechanism of hypersensitivity, and specifically whether this was an immunoglobulin (Ig)E- or IgG-mediated process. After completion of data collection in the first study,<sup>9</sup> protocol