Editorial

Regionalisation of critical care: can we sustain an intensive care unit in every hospital?

Background

Critical care is a complex and resource-intensive discipline, that underpins many hospital services but is itself dependent on diagnostic and interventional support from other specialities. In the UK, the traditional assumption is that a hospital of any size offering acute or complex care will require, and support, an adult intensive care unit (ICU). However, this is increasingly challenged by a number of healthcare trends, including the need to sustain a specialist workforce [1] while meeting evolving critical care standards [2, 3], and the impact of reconfiguration in the many specialities that refer patients to, and support, intensive care. It may be timely to examine the drivers, potential impact and public acceptability of regionalised ('hub and spoke') models in adult critical care.

At its simplest, regionalisation is already well established in the case of highly-specialised referral settings such as neurosciences and cardiothoracic surgery, and the specialist critical care that supports them. With such specialised services, the need for specialist rotas, and the logistical impracticality of delivering such care at every local hospital, are historically established and intuitive for both professionals and public.

In a study of patients' family attitudes in one such setting, published in this issue of *Anaesthesia*, Chieregato and colleagues describe an attitude survey of the next of kin of 213 consecutive patients admitted to a networked neurosurgical 'hub' ICU in Italy [4]. The service covers approximately one million inhabitants, receiving referrals from six 'spoke' hospitals, and transfers patients back to their originating ICU once specialist treatment is complete. This is similar to the operational function and catchment area of many UK specialist tertiary referral units.

Of the next of kin of those patients returned to 'spoke' hospital ICUs, surveyed one year after admission, 67.4% would have preferred their family member to have remained at the specialist centre until ICU discharge, most commonly citing continuity and quality of care. The results may have been confounded in this case by the availability of certain pastoral care elements preferentially at the hub site, such as a liberal visiting policy and an emphasis on daily communication. The study does not compare next of kin characteristics, which may influence responses (for example, geographic proximity, demographics and socio-economic status). Another possible limitation is that the named next of kin may not be the most representative family member or carer. The applicability of the findings to a British setting may be subject to societal differences, with historically very high levels of expectation and loyalty toward local district general hospital care among the UK public.

The authors comment that regular interaction between sites, and assurance of shared quality and continuity across a region, may help public acceptance of care pathways spanning multiple sites, pointing to clinical networks as a strategy for achieving shared standards. They also usefully highlight the often-overlooked element of post-critical care rehabilitation, now recognised as an essential element of the critical care pathway [5], which requires integration with healthcare systems close to the patient's home – a potential benefit of early repatriation.

Should regional ICUs be a primary goal?

Chieregato et al.'s study examines just one aspect of the hub-spoke organisation of critical care, in the context of the highly specialised, relatively low-volume clinical setting of neurosciences, where the concentration of critical care to a few sites

is driven by regionalisation of the referral speciality, and where the rationale is easily understood. More broadly, international academic discussion has focused on the case for, or against, regionalisation of critical care (the creation of hub and spoke ICUs) as a primary goal in itself, independent of referral speciality [6, 7]. The evidence for clinical volume-outcome benefits in critical care is conflicting [8] and may be confounded by international variation in hospitals' organisation and staffing models. A recent UK retrospective cohort study showed a positive volume-outcome relationship in 104 844 admissions requiring mechanical ventilation in general critical care units [9]. Volume-outcome benefits may be influenced by diagnostic subgroup and severity [9, 10], indicating a possible rationale for selective escalation. Conversely, a study of 5131 non-surgical admissions to US Veterans Administration hospitals, with shared organisational and governance attributes, showed unifomity of outcomes independent of case volume, suggesting that evidence-based practice and standardisation of staffing care may mitigate variation by unit size [11].

Disadvantages of critical care regionalisation may include: the distance of transfer and delays in access; the risk of overwhelming the capacity of destination hospitals; strain on patients' families and carers; and the clinical risks inherent in inter-site transfer of critically ill patients, for which data are still poor in adults [12]. The clinical risks may be controlled through well-organised ICU co-ordination and retrieval systems, already seen in paediatric critical care practice [13], but adult case volumes are higher and patterns of demand more complex. In practice, there are potential barriers to implementation [14], and a scarcity of evidence that reconfiguration of intensive care services improves outcomes in isolation. Primary regionalisation of adult general critical care is therefore not straightforward, and only one of a number of potential reorganisation strategies in critical care [15].

A more complex picture

We believe that changes to the landscape of adult critical care in the UK are more likely to occur as a secondary phenomenon, driven by increasing regionalisation of the clinical disciplines that refer to and support ICU. The earliest, and simplest, case of specialist tertiary services – neurosciences – has already been cited. We are now in the middle of a second wave of reconfiguration, in which services that were previously regarded as local and widely-distributed are undergoing the same transformation into networked regionalised systems. Notable examples include trauma care, stroke care, coronary angioplasty, interventional radiology and vascular surgery. This change is driven by increasing recognition of volume-outcome benefits in the primary specialities, as well as the need for specialist infrastructure and staffing, with increasing emphasis on fully sustainable subspeciality consultant rotas (rather than isolated local experts), and amplified (in the UK) by the increasingly selective placement of speciality-based postgraduate medical trainees into designated centres. Such changes impact only selectively on critical care, insofar as adequate capacity must be planned and provided at the destination hospitals and seamless referral and transfer pathways must be established to ensure that ICU patients have access to such services, regardless of site. However, in general, in this second wave of consolidation the function and viability of the referring local hospitals have not been affected, since these subspeciality patients tend to form a minority of a general hospital ICU's casemix.

In the next phase, by contrast, we are likely to see more radical changes. Emerging clinical standards in areas such as unscheduled and high-risk surgery [16, 17], and changing social and political expectations toward seven-day, consultant-delivered care [18], will tend to drive increasing regionalisation of services previously regarded as core, 'bread and butter' clinical activity for a local general hospital. A key example is emergency abdominal surgery, which in turn has implications for acute and emergency medicine, and associated diagnostics and interventions such as 24-h imaging and endoscopy. The withdrawal of such former core specialities from some sites is likely to impact on the viability of local ICUs, both through falling caseload – with accompanying difficulties in maintaining staff census, professional skills and training status – and through the withdrawal of local clinical services that previously supported ICU patients.

Imminent challenges

An emerging requirement, therefore, is to provide safe, sustainable

critical care to support clinical services such as acute medicine, and elective peri-operative care of patients with co-morbidities, at sites that can no longer support a full ICU. This may be through the evolution of treat-and-transfer systems where a local hospital retains the ability to resuscitate and transfer a patient to a regional critical care centre via established local facilities and a planned pathway, or through tiered regionalisation of ICUs, such that critical care in some form can be initiated and maintained at many sites, but selected patient cohorts are transferred to high-volume, high-capability regional hubs according to risk, severity, or disease type [15]. There are international precedents, most notably in healthcare systems featuring a mixture of urban centres and widely dispersed populations serviced by hub and spoke models, such as Canada and Australia, but also in the densely urbanised setting of Japan, where governmental policy, more than geography, has driven the majority of critical care to be delivered in academic centres since 1993 [19].

A complementary strategy may be to reorganise the 'front door' – in other words, to reconfigure and reduce the number of acute hospitals with emergency departments and realign them to a smaller number of high-acuity sites featuring multiple co-located, regionalised specialities, thus reducing inter-hospital transfers by admitting emergency patients directly to hospitals with the appropriate facilities. Clearly, this is a process with major financial, social and political impact, and is unlikely to be driven by critical care alone. An example is emerging in North West London, where an ambitious reconfiguration plan includes concentrating unscheduled care, currently spread across nine hospitals with emergency departments covering a population of nearly two million, into five 'major acute' sites and a constellation of local hospitals, elective centres, and specialist hospitals [20], with an inevitable realignment of critical care. Across the country, there is likely to be a diversity of solutions according to local circumstances and policy, varying from primary care-led local hospitals with no acute services or critical care, through to intermediate solutions involving hospitals continuing to provide selective acute and elective services, backed by well-planned access to critical care skills and resources. A particularly important question is whether acute medicine can function without a co-located ICU.

Underlying principles

Amidst this complexity, there are some simple fixed points. While generally accepting of concentration of specialist services at major hubs, the public still expects some form of local hospital care with reasonable geographic access. Whether or not every site can sustain a full ICU, it remains the case that patients with critical illness, either at admission or arising during a hospital stay, have a right to early recognition of their severity, to prompt access to critical care skills and decision-making, including appropriate admission selection, and to organised, timely access to safe facilities. Where inter-site transfers are required, they should take place via a standardised, audited system with trained staff, and destination hospitals should have sufficient capacity to assure seamless transfer by pre-agreed pathways into a designated bed, rather than ad-hoc bed-finding and delay. During their ICU stay, patients should receive best-practice care, in clinical areas that are fully compliant with extant standards and workforce requirements, and during their recovery they should benefit from an integrated approach to post-critical illness rehabilitation, working closely with services close to their home. Throughout the pathway, which may involve several sites, patients should benefit from effective handover and shared standards between sites and organisations.

The solutions and means by which these goals are delivered will vary. Some may be familiar, such as the existing close professional collaboration between critical care and anaesthesia; others may involve non-traditional working patterns, such as rotation or outreach of intensivists between hub sites and spoke hospitals, including those without an ICU. Meanwhile, critical care telemedicine, while still controversial, is an increasingly well-studied modality with evidence of benefit [21], and may gain a wider mandate with new service configurations. Even currently radical options such as robotic telepresence may prove to be effective [22] and well-accepted [23].

Most importantly, however, human factors, communications and

culture will be essential to the success of organisational or technological changes. As suggested by Chieregato and colleagues and demonstrated elsewhere, regional networking and collaboration provides a mechanism for shared service improvement and quality assurance [24], potentially levelling differences in outcome [10]. This is consistent with the successful experience of critical care networks in many parts of England and Wales since 2001. Collaboration, mutual familiarity, joint learning and a shared culture will be key to ensuring successful and seamless regional delivery of critical care, regardless of the exact configuration of facilities.

Summary

Changes in clinical practice, technology, workforce and standards are driving a secular trend for medical and surgical services to become regionalised: in other words, concentrated at regional hub sites. This, in parallel with emerging standards and workforce factors, is likely to drive a trend toward regionalisation of critical care as a secondary phenomenon, side-stepping the long-standing but somewhat abstract debate over the desirability of a hub and spoke model for critical care as a primary goal. Until now, the specialist referral services driving these changes have tended to be selective in casemix and low-volume in nature, and thus have had little effect on the viability of ICU in non-hub hospitals. However it is likely that further trends toward regionalisation of high-volume, high-impact clinical activities, such as emergency surgery, will trigger more extensive changes in the critical care landscape than has formerly been seen, and will challenge current assumptions about critical care facilities and working practices for both intensivists and anaesthetists. There is a balance to be struck between access to local services, and the need for sustainable, high-quality, specialist-led healthcare that is – by its nature, and the associated workforce and logistical factors – likely to be deliverable at fewer sites than at present. The public are the ultimate stakeholders in this process – including patients' families, as Chieregato et al.'s study reminds us. Nearly one and a half decades after a UK governmental mandate to implement 'critical care without [departmental] walls' [25], it may be time to examine further 'critical care across hospital perimeters'.

Competing interests

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Editorial

Quality of Life: changing the face of outcome measurements in critical care

Born from a concern about the cost and quality of healthcare, and further emphasised by an increasing awareness of the variability of clinical practice throughout different jurisdictions, interest in measuring and evaluating the effect of clinical interventions has grown consistently over the last two decades. Measuring effectiveness serves as an attempt to ensure that healthcare systems are transparent and accountable to both those who pay for them, and those who use them. While outcome measures continue to rely heavily on the use of mortality as a marker of performance, recent evidence demonstrates that both the UK and the USA have a growing interest in measuring patient function, rather than merely physiological endpoints [1].

This move towards using functional outcome in performance

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The hub and spoke model of intensive care regionalisation: hoping the wheels dont come off

In their recent editorial, Suntharalingam et al. suggest that the rationale behind recent trends towards 'spoke and hub' regionalisation of services is exemplified by specialist intensive care units [1]. Specialist units provide volume-outcome benefits for those patients fortunate to be managed at the hub from the outset, but not necessarily for the higher proportion of patients starting their care journey at spoke hospitals, because of transport distances and delays, limited hub hospital capacity, strain on patient families and risks inherent in critical care transfers. Furthermore, regionalisation reduces the speed of diagnosis and initial critical care treatment for spoke patients by intensivists, in favour of less experienced care providers in acute medical or surgical units.

The authors suggest that new strategies will need to be developed to care for sick patients at spoke hospitals, including ICU outreach teams, intensivist rotations, critical care telemedicine and 'close collaboration between critical care and anaesthesia'. However, this last strategy, I fear, will inevitably be translated as 'junior anaesthetists managing critically ill patients in 'pop-up ICUs' (operating theatres, recovery units, emergency departments) at spoke hospitals that are no longer appropriately equipped or staffed to cope with such patients until transfer can be arranged, with a similarly 'close collaboration' involving junior anaesthetists transferring very many patients to and from hub and spoke centres as well. Perhaps the brakes need to be applied to any hub and spoke model until these details have more carefully planned.

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Levobupivacaine ampoule labelling about sterility

At the end of a minor surgical procedure under general anaesthesia, the surgeon requested local anaesthetic to infiltrate around an incision. The anaesthetist proffered a 10-ml ampoule of levobupivacaine 0.75% (Chirocaine®, Abbott Ltd, Maidenhead, UK) to the scrub nurse. However, the scrub nurse refused to accept the ampoule from its blister pack, stating that another anaesthetist had previously informed her that the levobupivacaine ampoules are not sterile.

On checking the labelling on the levobupivacaine blister pack (Fig. 1), the ampoule itself and the multi-pack box, the anaesthetist discovered that at no place did it actually state the ampoules inside the blister pack are sterile. This is in contrast to bupivacaine ampoule blister packs (Marcain Polyamp®, AstraZeneca Ltd, Luton, UK), where the label clearly states 'Sterile until opened' (Fig. 2).

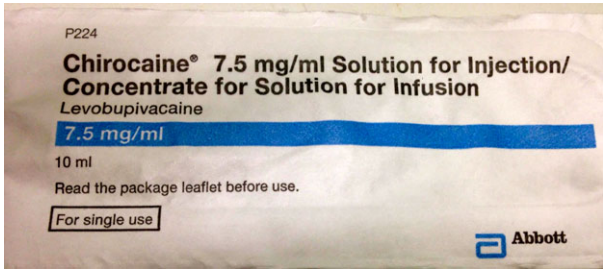

Figure 1 Levobupivacaine packaging.

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Original Article

Satisfaction of patients' next of kin in a 'Hub & Spoke' ICU network

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Summary

This study aimed to gauge the opinions of patients' next of kin regarding transfer of patients from the specialist 'Hub' intensive care unit, to 'Spoke' intensive care units near home. We included 213 consecutive patients with severe trauma or severe acute neurological conditions admitted to the Hub intensive care unit over a 21-month period, who were repatriated to Spoke intensive care units for ongoing intensive care. One year after admission to the Hub intensive care unit, two thirds of patients' next of kin said they would have preferred patients to have been treated only in the Hub intensive care unit, and not repatriated. They perceived Hub intensive care unit care to be important, and would have preferred that their relatives be hospitalised there until intensive treatment was completed. The next of kin's preference was associated with severe acute neurological conditions ($p \leq 0.0001$). Although centralised Hub & Spoke intensive care unit networks are appropriate to ensure specialised care, repatriation to local hospitals may not be appropriate for patients with severe neurological conditions.

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Introduction

Specialist intensive care units (ICUs) have been advocated to treat patients with particular needs, e.g. neurological ICUs to treat patients with severe neurological disease. They are, however, commonly subject to significant pressure on their beds, and in Italy's National Health Service, specialist ICUs seldom have beds available, for two reasons: a shortage of specialist ICU beds; and a shortage of intermediate care beds to which to transfer patients following their initial treatment. Therefore, to allow the admission of new patients, specialist ICUs must transfer patients to non-specialist ICUs after emergency surgical and medical treatment has been completed ('decentralisation' or repatriation of patients).

The North Italian Region Emilia-Romagna (capital Bologna) operates a 'Hub & Spoke' hospital system [1, 2]. The Hub ICU treats major trauma and neurosurgical patients, who are centralised to the Hub ICU. Centralising selected patients allows increased volume of activity for specific conditions, and improves patient outcomes [3–8]. Spoke ICUs admit

patients with less severe disease, patients not expected to benefit from care in specialist ICUs, and patients discharged from the Hub ICU. Repatriation of patients may hinder continuity of care, and has, to our knowledge, not been the object of research.

Hub ICU staff often observed that the next of kin of patients repatriated from Hub to Spoke ICUs were unhappy with this decision at the time of discharge. Many of them, seen at follow up one year later, remained dissatisfied with the decision to transfer the patient the year before. Dissatisfaction regarding transfer was not seen in the next of kin of patients discharged within the Hub hospital, i.e. from Hub ICU to Hub ward.

We hypothesised that the next of kin of patients initially transferred to the Hub ICU for specialist care would be more satisfied with care that is completed in the Hub ICU, as opposed to being repatriated from Hub to Spoke ICUs before completion of intensive care. The question can be framed as to whether, for any given patient, a one-ICU model is superior to a two-ICUs model, and is reminiscent of the 'one patient–one anaesthetist' or 'one patient–two anaesthetists' dilemma [9]. A secondary aim of the study was to identify the reasons given by patients' next of kin for their choices, and determine which clinical factors were associated with the above choices.

Methods

We conducted a cross-sectional study among the next of kin of patients who had been transferred to Spoke ICUs near to their homes, to evaluate their preference for a one-ICU model rather than for a two-ICUs model. The local Ethics Committee did not deem approval necessary for this observational study. Patients' next of kin accepted and signed our ICUs' policy regarding data collection and follow-up interviews. Patient data were retrospectively obtained from

Distance, travelling times and cost (EUR, return trip) from Hub to Spoke ICU (data from http://www.viamichelin.it, accessed 08/02/2014):

Rimini – Cesena:	72 km	95 min	12.5 EUR
Riccione – Cesena:	88 km	90 min	16.5 EUR
Ravenna – Cesena:	72 km	90 min	11.5 EUR
Lugo – Cesena:	112 km	115 min	18.3 EUR
Faenza – Cesena:	88 km	85 min	15.2 EUR
Forlì – Cesena:	38 km	80 min	6.4 EUR

Figure 1 The Emilia-Romagna region in Northern Italy. The Hub & Spoke system is located in the South-east of the region. At its centre lies the city of Cesena, with its trauma centre and Hub ICU. The towns with Spoke ICUs surrounding the Hub in Cesena are shown with red dots.

the ICU database where data are routinely collected, regardless of study enrolment. Follow-up consisted of a single telephone interview with the patient's next of kin one year after Hub ICU admission.

In Romagna (population one million, on Italy's North-Eastern Coast), patients with major trauma or severe acute neurological conditions are referred to the trauma centre in the city of Cesena, which has 11 ICU beds [10, 11]. Scarcity of beds dictates that to admit new patients, the Hub ICU must transfer patients to one of the six Spoke ICUs (46 beds in Ravenna, Lugo, Faenza, Forlì, Rimini, and Riccione) as soon as clinically possible. Figure 1 shows the position of the above city/towns on a map.

At the time of the study, only the Hub ICU adopted a liberal visiting policy [12]. In addition, communication was prioritised, and patients' next of kin were informed about diagnosis, management, disease evolution and expected outcome. They were also informed upon admission that as soon as the patient no longer needed specialist ICU care, the patient would be transferred to a general Spoke ICU. Patients' next of kin were routinely interviewed by telephone one year after Hub ICU admission and, if possible, patients were invited to attend outpatient follow-up.

Criteria for repatriating neurosurgical and neurotrauma patients included completion of surgery, and completion of treatment of: (a) intracranial hypertension; (b) macrovascular hypoperfusion (subarachnoid haemorrhage (SAH) vasospasm); (c) electrical and clinical seizures; and (d) dysautonomic syndromes.

The following reasons were not considered contraindications to repatriation: delayed recovery of consciousness; mechanical ventilation; potential development of hydrocephalus; infections under targeted treatment; decompressive craniectomy and prospective bone vault reconstruction; spinal cord injury; and need for non-damage control surgery for associated traumatic injuries.

We evaluated all consecutive patients admitted to the Hub ICU between September 2006 and May 2008 (21 months), and included survivors who did not live in the Hub area.

We prepared a questionnaire for patients' next of kin (Appendix 1), presenting either the one-ICU or the two-ICUs model. Reasons for choices explored the following: the importance given by patients' next of kin to continuity of care; advantages for them if their relative was in a hospital closer to home; the importance of reduced travel expenses after their relative was repatriated; and gratitude towards the initial caregivers in the specialist centre.

The questionnaire was mailed to participants one year after admission to the Hub ICU, and was not anonymous. An extended Glasgow Outcome Scale (GOSe) evaluation was made on the telephone, to measure the degree of the patient's disability [13]. The GOSe score was converted into the five-category GOS [14]. After three unsuccessful telephone calls, patients were considered non-responders. The intensity of specialised care for intracranial hypertension was measured with the local therapeutic intervention level [15]. Intensity of care during ICU stay was measured with the nine equivalents of nursing manpower use score [16].

We recorded data concerning diagnosis, disease severity and management for each patient, and compared the characteristics of patients not living in the Hub ICU area who completed their intensive care in the specialist unit, with those also not living in the Hub ICU area, but who were repatriated to a Spoke ICU. This was to evaluate potential bias due to studying only the next of kin of patients who were actually transferred to a Spoke ICU near home, and not including those of patients who may have needed to be repatriated, but were not.

We chose our sample size after postulating a 60% preference for the one-ICU model, with values for α of 0.05, and β of 0.20; each group needed 95 patients to achieve adequate power (MedCalc 13.1.2.0; MedCalc Software bvba, Ostend, Belgium). Choices for the one-ICU vs two-ICUs models were subjected to descriptive analysis. Factors related to diagnosis and treatment potentially associated with relatives' choices were subjected to univariate analysis (DataDesk 6.3.1, Ithaca, NY, USA). Patient outcome was analysed as a factor influencing responders' choice. Comparative analyses were made by means of parametric tests for scalar variables and chi-squared tests for categorical variables. A binary logistic regression model was used to see which variables were independently associated in the

univariate analysis ($p < 0.10$) with one of the two scenarios, or independently predicted the one-ICU scenario (IBM SPSS Statistics, Version 19, Armonk, NY, USA).

The categorised variables included in a backward regression logistic (exit level 0.10) were: patient's age (years); APACHE Chronic score [17]; ICU length of stay (LOS) longer or equal to 6 days; brain disease (neurosurgical or not) vs extra-cranial injuries with mild traumatic brain injury (TBI); intracranial pressure (ICP) monitoring; intensity of care to manage high ICP; and disability at one year.

Results

Eight hundred and seventy-seven patients were admitted to the Hub ICU during the study period, of whom 86 (9.8%) died in the ICU. Of the 791 patients discharged alive, 588 (74%) did not live in the Hub area. Most patients (n = 375, 63.8%) were transferred to wards within the same Hub hospital, whereas 213 (36.2%) of them were repatriated to Spoke ICUs. These 213 patients were the subjects in this study. Seventeen patients (8%) were lost to follow-up at 12 months, and consequently data for 196 patients were analysed. Patients' details are summarised in Table 1. Patients not living in the Hub area, but who completed all their treatment at the Hub ICU, were younger, and had less complex admission syndromes. They predominantly had extra-cranial lesions or mild TBI, were usually admitted for elective surgery, had a shorter LOS, and needed a lower intensity of care while in the ICU.

Among the 196 patients who were repatriated, a majority of respondents (n = 132, 67%) preferred the one-ICU model, whereas the remainder (n = 64, 33%) preferred the two-ICUs. The distribution of reasons for selecting each model is shown in Fig. 2. Two reasons were selected equally often: 'because physicians treating patients from the onset know the patients and what improvement can be expected' and 'because the specialist ICU manages patients in the more difficult phase, and it is a better ICU'. The above two choices accounted for 65% of preferences. The reasons given by patients' next of kin who selected the two-ICUs model were 'because it is easier and less costly to visit a patient in an ICU near home' (n = 36, 58%), and 'because, trusting the first ICU, we believed transferring the patient meant the acute phase was over' (n = 16, 26%).

Patients' next of kin who chose the one-ICU model rarely selected reasons related to trust: answer (2): 'because otherwise it is impossible to establish a doctor-patient-next of kin relationship based upon trust' (n = 1, 0.7%) and answer (7) 'because we felt abandoned' (n = 3, 2.2%).

Patient variables associated with the one-ICU choice are shown in Table 2. Patients' next of kin preferred the one-ICU model when patients were younger, had longer LOS in the Hub ICU, if there was a high intensity of care, and if ICP was monitored. Conversely, when patients had chronic disabling diseases, repatriation with the two-ICUs model was preferred. Relatives of patients with TBI preferred to complete their treatment in the specialist ICU, and

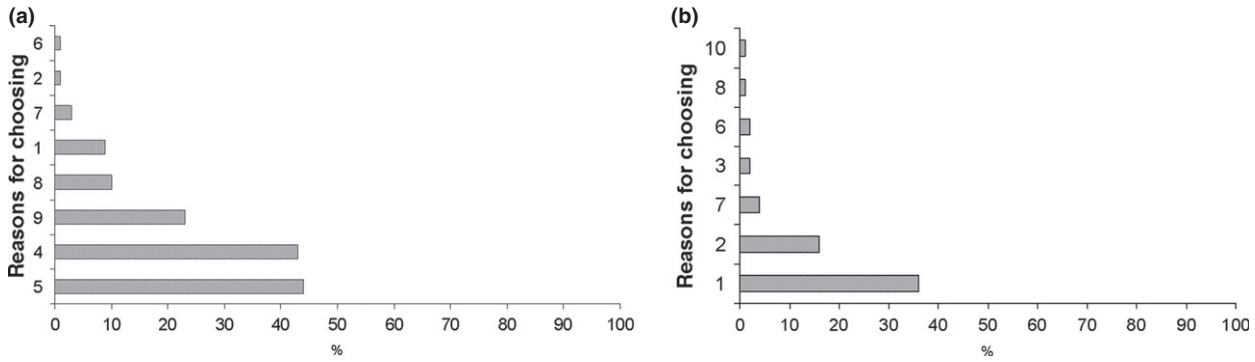

Figure 2 Reasons for choosing a) the one-ICU model vs b) the two-ICUs model. See Appendix 1 to match numbers on the y-axis with the reasons given.

Table 1 Details of 588 patients not living in the Hub ICU area, and potentially eligible for transfer to a Spoke hospital near home. Univariate analysis compares characteristics of patients transferred to Spoke hospitals with respect to those transferred within the Hub hospital. Values are mean (SD), median (IQR [range]) or number (proportion).

	Transferred to Spoke hospital (n = 213; 36.2%)	Transferred within Hub hospital (n = 375; 63.8%)	p value
Age; years	55.4 (19.7) 60 (39–71 [11–92])	47.4 (21) 49 (32–66 [1–86])	≤ 0.0001
Male	130 (40.4%)	192 (59.6%)	0.0213
Female	83 (31.2%)	183 (68.8%)	
Type of admission			
Elective	25 (14.5%)	148 (85.5%)	≤ 0.0001
Emergency	188 (46.0%)	221 (54.0%)	
Length of stay; days	11.6 (8.2) 10 (5–17 [1–46])	4.9 (6.4) 2 (2–4 [1–48])	≤ 0.0001
Length of stay > 6 days	147 (66.8%)	73 (33.2%)	≤ 0.0001
Reason for admission			
Extra-cranial injury	24 (30.8%)	54 (69.2%)	≤ 0.0001
Mild TBI	18 (30.0%)	42 (70.0%)	
Moderate TBI	31 (47.7%)	34 (52.3%)	
Severe TBI	48 (66.7%)	24 (33.3%)	
ICH	26 (76.5%)	8 (23.5%)	
SAH or AVM or elective aneurysm	42 (41.2%)	60 (58.8%)	
Other	24 (13.6%)	152 (86.4%)	
ICP monitoring	107 (59.4%)	73 (40.6%)	≤ 0.0001
TIL			
No therapy	64 (21.1%)	240 (78.9%)	≤ 0.0001
Standard	61 (38.9%)	96 (61.1%)	
Reinforced	60 (72.3%)	23 (27.7%)	
Extreme for refractory ICP	26 (66.7%)	13 (33.3%)	
NEMS			
Maximal value during ICU stay	45 (9.4) 45 (38–52 [18–63])	34.3 (10.6) 33 (27–39 [12–57])	≤ 0.0001
Transferred			
ICU	213 (86.2%)	34 (13.8%)	≤ 0.0001
Regular ward	0	337 (100%)	
Rehabilitation unit	0	4 (100%)	
Consciousness at 'Hub' ICU discharge			
Obeying simple commands (motor GCS equal to 6)	84 (19.7%)	343 (80.3%)	≤ 0.0001

TBI, traumatic brain injury; ICH, intracerebral spontaneous haematoma; SAH, subarachnoid haemorrhage; AVM, artero venous malformation; ICP, intracranial pressure; TIL, therapeutic intervention level; NEMS, nine equivalents of nursing manpower use score; ICU, intensive care unit; GCS, glasgow coma scale.

the preference rate for the one-ICU model increased with severity of TBI: mild TBI, 50%; moderate TBI, 63%; severe TBI, 77%. Similarly, in patients referred with cerebrovascular disease (subarachnoid haemorrhage, arterio-venous malformations, elective aneurysmal procedures), the preference for completing treatment in one ICU was very high (83%).

The distribution of preferences was dissimilar in different Spoke ICUs. Patients' next of kin who lived outside Romagna were least likely to prefer the one-ICU model, and favoured repatriation.

Multivariate analysis (Table 3) confirmed that older age, LOS over six days, serious neurological disease, transfer to an ICU in Romagna, death, vegetative state or disability at one year were significantly and independently associated with preferring the one-ICU model.

Discussion

It is well known that increased volume of activity improves patient outcome: this is one of the foundations of trauma systems, and of Hub & Spoke ICU networks.

Table 2 Univariate analysis of 196 patients who were repatriated. Data associated with satisfaction with the one-ICU vs two-ICUs model. Values are mean (SD), median (IQR [range]) or number (proportion).

	One-ICU (n = 132; 67.4%)	Two-ICUs (n = 64; 32.6%)	p value
Age; years	55.6 (19.3) 60.5 (42–70.5 [11–86])	61.7 (18.9) 68.5 (48.5–74 [18–92])	0.0378
Male	82 (68.3%)	38 (31.7%)	0.711
Female	50 (65.8%)	26 (34.2%)	
APACHE Chronic score rating			
No functional limitation	76 (65.5%)	40 (34.5%)	0.0454
Mild to moderate limitation	40 (70.2%)	17 (29.8%)	
Serious but not incapacitating restriction of activity	16 (80.0%)	4 (20.0%)	
Severe restriction of activity	0	3 (100%)	
Type of admission			
Elective	13 (69.4%)	6 (31.6%)	0.9163
Emergency	119 (67.2%)	58 (32.8%)	
Length of stay; days	12.9 (8.4) 11 (7–17 [1–46])	9.5 (7.3) 7 (4–13 [2–32])	0.0065
Length of stay > 6 days	104 (74.8)	35 (25.2)	0.0005
Reasons for admission			
Extra-cranial injury	9 (42.9%)	12 (57.1%)	0.0247
Mild TBI	7 (50.0%)	7 (50.0%)	
Moderate TBI	19 (63.3%)	11 (36.7%)	
Severe TBI	37 (77.1%)	11 (22.9%)	
ICH	18 (69.2%)	8 (30.8%)	
SAH or AVM or elective aneurysm	29 (82.9%)	6 (17.1%)	
Other	13 (59.1%)	9 (40.9%)	
ICP monitoring	78 (78.8%)	21 (21.2%)	0.0006
TIL			
No therapy	31 (55.4%)	25 (44.6%)	0.0833
Standard	39 (67.2%)	19 (32.8%)	
Reinforced	41 (73.2%)	15 (26.8%)	
Extreme for refractory ICP	21 (80.8%)	5 (19.2%)	
NEMS			
Maximal value during ICU stay	46.7 (9.35) 46 (39–57 [18–63])	42.5 (8.2) 40 (38–48.5 [27–57])	0.0024
Spoke ICUs			
Outside Romagna region	5 (31.2%)	11 (68.8%)	0.0108
ICU A	2 (40.0%)	3 (60.0%)	
ICU B	15 (55.6%)	12 (44.4%)	
ICU C	18 (69.2%)	8 (30.8%)	
ICU D	32 (71.1%)	13 (28.9%)	
ICU E	18 (72%)	7 (28%)	
ICU F	23 (76.7%)	7 (23.3%)	
ICU G	19 (86.4%)	3 (13.6%)	
Consciousness at Hub ICU discharge			
Patient obeys simple commands (motor GCS equal to 6)	42 (62.7%)	25 (37.3%)	0.3337
Glasgow Outcome Scale (at 1 year)			
Dead	34 (61.8%)	21 (38.2%)	0.2297
Vegetative state	6 (66.7%)	3 (33.3%)	
Severe disability	39 (76.5%)	12 (23.5%)	
Moderate disability	31 (73.8%)	11 (26.2%)	
Good recovery	22 (56.4%)	17 (43.6%)	

TBI, traumatic brain injury; ICH, intracerebral spontaneous haematoma; SAH, subarachnoid haemorrhage; AVM, artero venous malformation; ICP, intracranial pressure; TIL, therapeutic intervention level; NEMS, nine equivalents of nursing manpower use score; ICU, intensive care unit; GCS, glasgow coma scale.

Table 3 Logistic regression analysis of patient data associated with patient or next of kin preferring the one-ICU scenario. Values are number (95% CI).

	OR	p value
Age; years	0.98 (0.96–0.99)	0.020
Spoke ICU within Romagna	3.547 (1.64–7.68)	0.001
Length of stay > 6 days	2.16 (1.07–4.39)	0.032
Death, vegetative state, severe or moderate disability at 12 months	2.35 (10.17–5.43)	0.045
Neurosurgical syndrome or disease (except mild traumatic brain injury)	2.890 (1.25–6.71)	0.013

Patients with severe acute conditions are initially treated in the specialist Hub ICU (centralised), and then transferred to Spoke ICUs (decentralised or repatriated) as soon as beds are needed in the Hub ICU. The degree of satisfaction of the next of kin of patients who are repatriated has, to our knowledge, not been evaluated. This study reveals that most patients' next of kin are happier if treatment is completed in the Hub ICU, rather than initially in the Hub and then in a Spoke ICU as soon as beds are needed in the Hub ICU. This is particularly true if patients are affected by severe acute neurological conditions.

Clinical patient-related factors are associated with the next of kin's preference for a one-ICU model. Neurosurgical conditions and moderate/severe TBI decreased satisfaction with a two-ICUs model, confirming that relatives understand the importance of specialised care, particularly when the neurological syndrome is more complex. Older patient age is associated with relatives' preferring repatriation and a two-ICUs model. A longer LOS in the Hub ICU increases preference for the one-ICU model. Longer LOS is associated with increased disease severity and complexity of care. Patients' next of kin perceived that the higher the degree of clinical complexity, the more appropriate the one-ICU scenario was. Living far from the Hub ICU increased the number of relatives choosing the two-ICUs model, perhaps believing that the benefits expected from a longer LOS in the Hub ICU do not justify the distance from home, when this distance is large.

The next of kin of half the patients who recovered well at one year preferred the one-ICU model. Conversely, the next of kin of patients who died after discharge, or had disability, also chose the one-ICU model, probably reflecting the expectation that a longer LOS in the Hub ICU may have improved outcome.

Centralising patients to centres with high volumes of activity is associated with better outcome, both for TBI [4–7] and after neurosurgery [8]. For a Hub & Spoke ICU system to work well, patients who no longer require the specific skills of the specialist ICU need to be repatriated as soon as clinically feasible. The fact that patients' next of kin prefer the one-ICU model, however, underlines the difficulties and tensions inherent in this system. This study shows situations where improvement may be achieved. The association between preferring the one-ICU model and severity of neurological disease highlights that in severe conditions, discontinuity of care may be perceived as a problem.

The natural history of neurological conditions spans months or years. As a consequence, neuro-intensive care should be followed by specialised intermediate and rehabilitation care, with the same high standards of care as the initial management [17–20]. Our data suggest that the relatives of patients repatriated to Spoke ICUs would welcome being near home, should continuity and quality of care be guaranteed. Even in patients who made a good recovery, 56% of patients' next of kin chose the one-ICU model. This suggests that they perceive discontinuity of care to be an issue, even for patients with a good outcome. It is also likely that successful patient management in the Hub ICU generates satisfaction with that unit. The link between clinical factors (disease severity, young age, outcome), and choosing the one-ICU model supports the hypothesis that an appreciation of clinical conditions guide the choices made by relatives responding to the questionnaire.

There are potential criticisms of this study. We questioned the next of kin of selected patients to obtain an answer to the specific question: 'What are the opinions of next of kin of patients who were actually moved to an ICU closer to home'. The broader question 'What are the opinions of next of kin of patients who could have been moved to an ICU closer to home' would have required asking the next of kin of all patients admitted to the Hub ICU. We are thus

unable to determine if the relatives of patients who could have been repatriated, but were not, would have preferred to complete treatment in the specialist ICU. In addition, the questionnaire was closed to facilitate analysis. This is a potential drawback, as respondents may have had reasons for their choices that were not captured by the questionnaire.

Another source of bias may derive from the 8% of patients lost to follow-up. However, this rate is lower than in similar papers reporting outcome data collection. Further limitations of the study may be related to ethnic, cultural, social, economic and geographical factors affecting the respondents, which have not been taken into account, and may have influenced their choices. However, the fact that the study was carried out in a well-defined area, with a well-defined healthcare organisation, adds credibility to the study, and reduces possible confounders. The results are thus presumably applicable to other Hub & Spoke ICU systems, and to specialist ICUs in tertiary care hospitals affected by shortages of both ICU and intermediate care beds.

In conclusion, the outcome data from our study suggest that patients' next of kin are more satisfied when those patients stay in specialist ICUs for longer, especially if they were admitted with a neurological syndrome. Transfer from a specialist Hub ICU to a non-specialist Spoke ICU is perceived as a drawback, perhaps due to concerns regarding discontinuity of care. This may undermine the function of centralised networks, which depend on patient flow. Further studies are needed to ascertain whether discontinuities following repatriation exist, and whether avoiding them would make a difference to patient outcome and entail less dissatisfaction among relatives.

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Competing interests

No external funding and no competing interests declared.

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Appendix 1

Questionnaire for patients' next of kin.

DATE: …….

PATIENT'S DATA: SURNAME ……. NAME …….

PARTICIPANT'S DATA: SURNAME …… NAME …….

Which of the following two scenarios do you think is best?
Choose only **ONE** reason you think explains your choice of only **ONE** scenario

SCENARIO A	
Tick here	The patient is treated in the same specialised ICU (Cesena) until he or she no longer needs Intensive Care

SCENARIO B	
As soon as the patient is stabilised he or she is transferred from the specialised ICU in Cesenato another ICU near home	*Tick here*

	REASONS FOR CHOOSING SCENARIO A	**REASONS FOR CHOOSING SCENARIO B**	
Tick ONCE below	*The patient stays in the **SAME** specialised ICU (Cesena) until he or she no longer needs intensive care*	*As soon as the patient is stabilised he or she is **transferred** from specialised ICU to a general ICU near home*	*Tick ONCE below*
	1) Because it is not right to transfer a patient before he or she recovers consciousness or breathes spontaneously	1) Because it is easier and less costly for us to have the patient in an ICU near home	
	2) Because otherwise a good doctor-patient-next of kin relationship cannot be created	2) Because since we trust the first ICU we believe transfer means the difficult part in the treatment is over	
	3) Because the physicians in the first ICU want to take care of the patient until he or she is conscious or self sufficient	3) Because at any rate the patient will be looked after by many other physicians in many other wards	
	4) Because the specialised ICU takes care of the patient during the critical phase and is anyway the best ICU	4) Because this makes us feel more at home	
	5) Because only the physicians who took care of the patient from the beginning knows him or her and what improvements are expected	5) Because peripheral ICUs are more human	
	6) Because it is easier to find out who is responsible in case things go wrong	6) Because every ICU has its skills, so the second ICU is better for patients who are recovering normal conditions	
	7) Because we feel abandoned otherwise	7) Because a specialised ICU is better in the acute phase, and a general ICU afterwards	
	8) Because an ICU which takes care of patients until they get better can see its own results and learn from its own work	8) Because when patients are seen by different doctors, in different wards, in different hospitals, new aspects can be caught and new treatments given	
	9) Because it is in the patients' rights to be taken care of by the same team which first saw them	9) Because two eyes see better than a single one	
	10) Because we fear transferring the patient can cause harm to him or her	10) Because if the patient is transferred this means he or she is improving	

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The hub and spoke model of intensive care regionalisation: hoping the wheels dont come off

In their recent editorial, Suntharalingam et al. suggest that the rationale behind recent trends towards 'spoke and hub' regionalisation of services is exemplified by specialist intensive care units [1]. Specialist units provide volume-outcome benefits for those patients fortunate to be managed at the hub from the outset, but not necessarily for the higher proportion of patients starting their care journey at spoke hospitals, because of transport distances and delays, limited hub hospital capacity, strain on patient families and risks inherent in critical care transfers. Furthermore, regionalisation reduces the speed of diagnosis and initial critical care treatment for spoke patients by intensivists, in favour of less experienced care providers in acute medical or surgical units.

The authors suggest that new strategies will need to be developed to care for sick patients at spoke hospitals, including ICU outreach teams, intensivist rotations, critical care telemedicine and 'close collaboration between critical care and anaesthesia'. However, this last strategy, I fear, will inevitably be translated as 'junior anaesthetists managing critically ill patients in 'pop-up ICUs' (operating theatres, recovery units, emergency departments) at spoke hospitals that are no longer appropriately equipped or staffed to cope with such patients until transfer can be arranged, with a similarly 'close collaboration' involving junior anaesthetists transferring very many patients to and from hub and spoke centres as well. Perhaps the brakes need to be applied to any hub and spoke model until these details have more carefully planned.

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Levobupivacaine ampoule labelling about sterility

At the end of a minor surgical procedure under general anaesthesia, the surgeon requested local anaesthetic to infiltrate around an incision. The anaesthetist proffered a 10-ml ampoule of levobupivacaine 0.75% (Chirocaine®, Abbott Ltd, Maidenhead, UK) to the scrub nurse. However, the scrub nurse refused to accept the ampoule from its blister pack, stating that another anaesthetist had previously informed her that the levobupivacaine ampoules are not sterile.

On checking the labelling on the levobupivacaine blister pack (Fig. 1), the ampoule itself and the multi-pack box, the anaesthetist discovered that at no place did it actually state the ampoules inside the blister pack are sterile. This is in contrast to bupivacaine ampoule blister packs (Marcain Polyamp®, AstraZeneca Ltd, Luton, UK), where the label clearly states 'Sterile until opened' (Fig. 2).

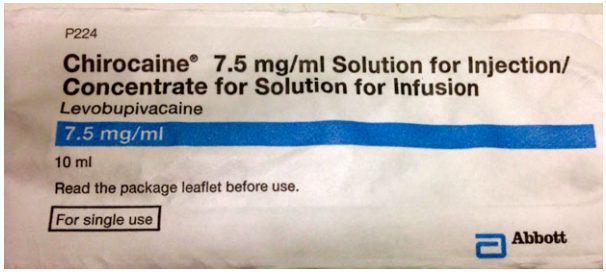

Figure 1 Levobupivacaine packaging.