

Geriatric Focused ERAS Nursing Practices in Open and Hybrid Aortic Vascular Surgery

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Background: Enhanced Recovery After Surgery (ERAS) pathways have been adapted for open and lower extremity vascular surgery and increasingly guide perioperative care for older adults. However, little is known about how perioperative nurses implement ERAS-consistent and geriatric-focused practices for older patients undergoing open and hybrid aortic procedures, particularly in hybrid operating room settings and in Chinese hospitals, where pathway maturity and geriatric integration may vary across centres.

Purpose: To describe perioperative nurses' implementation of ERAS-consistent and geriatric-focused nursing practices for older adults undergoing open and hybrid aortic vascular surgery in China, and to identify nurse- and organisation-level factors associated with higher implementation, with attention to modifiable determinants (training, ERAS pathways, staffing).

Methods: Registered nurses working in operating theatres/hybrid operating rooms, post-anaesthesia care units, intensive care/high-dependency units, vascular surgical wards and pre-assessment clinics in eight tertiary general hospitals in Shanxi Province, China, were surveyed between March and July 2024. The Geriatric-Focused Vascular ERAS Nursing Practices Questionnaire, developed from ERAS/SVS guidelines and geriatric surgery literature, measured nurse-reported implementation across perioperative domains, geriatric-focused elements, attitudes and perceived barriers. The instrument underwent expert review, pilot testing and internal consistency assessment, while more advanced psychometric testing was beyond the scope of this initial multicentre study. Data were analysed using descriptive statistics, group comparisons and multivariable linear regression; free-text responses were examined using inductive qualitative content analysis. The study was conceptually informed by a Donabedian structure-process-outcome framework and a capability-opportunity-motivation perspective on behaviour change.

Results: Of 640 eligible nurses, 428 provided analysable responses (usable response rate 66.9%). The global ERAS implementation score (1–5) was 3.41 (SD 0.49). Implementation was highest for intraoperative/post-anaesthesia practices (3.82, SD 0.61) and preoperative education/optimisation (3.63, SD 0.72), and lowest for frailty and cognitive/delirium assessment (2.71, SD 0.81). Routine frailty assessment was reported by 23.4% and routine use of structured delirium screening tools by 30.8%. Higher implementation was independently associated with ERAS-specific training ($B = 0.28, p < 0.001$), geriatric/frailty training ($B = 0.12, p = 0.008$), working in hospitals with a formal ERAS pathway ($B = 0.24, p < 0.001$), higher perceived staffing adequacy ($B = 0.09, p = 0.004$), and greater experience ($B = 0.04$ per 5 years, $p = 0.012$) (adjusted $R^2 = 0.38$). Qualitative findings highlighted ERAS as an “ideal rather than daily reality”, challenges in technology-dense environments, fragmented responsibilities, and the need for leadership and tailored education.

Conclusion: Perioperative nurses in these tertiary hospitals reported moderate implementation of ERAS-consistent care for older adults undergoing open and hybrid aortic vascular surgery, with substantial gaps in frailty assessment, delirium screening and geriatric-tailored practices. These gaps are clinically important because they may limit timely risk recognition and tailoring of perioperative care in a high-risk older surgical population. ERAS-specific and geriatric training, hospital-level ERAS pathways, perceived staffing adequacy and experience were associated with higher implementation and represent important modifiable targets, although causal relationships cannot be inferred from this cross-sectional survey.

Keywords: enhanced recovery after surgery, vascular nursing, aortic surgery, frailty, delirium, geriatric nursing

Introduction

Enhanced Recovery After Surgery (ERAS) is a multimodal, evidence-based approach to perioperative care designed to attenuate the surgical stress response, maintain physiological function and accelerate recovery. Large programmes and

meta-analyses across colorectal, hepatobiliary, urological and gynaecological surgery have shown that ERAS pathways can reduce length of stay by 30–50%, lower complication rates and decrease costs without increasing readmissions.¹ ERAS is explicitly framed as a multidisciplinary care system that combines guideline-based interventions with structured implementation and audit, and perioperative nurses are consistently identified as central actors in translating protocols into bedside practice.²

In vascular surgery, the ERAS Society and the Society for Vascular Surgery (SVS) have recently provided procedure-specific guidance. In 2022, an international expert panel published consensus recommendations for perioperative care in open aortic vascular surgery, structured around 36 ERAS elements across preadmission, preoperative, intraoperative and postoperative phases.³ In 2023, a companion framework was issued for infrainguinal lower extremity bypass surgery, and further statements have followed for major limb amputation.⁴ These documents emphasise several nursing-sensitive practices, including structured preoperative education, nutritional and anaemia optimisation, early mobilisation, multimodal analgesia, delirium prevention, early removal of drains and catheters and structured discharge planning.³

Despite these advances, the empirical evidence base for vascular ERAS remains relatively limited. A systematic review of ERAS pathways in vascular operations published in 2019 found only small, heterogeneous studies—mostly single-centre, non-randomised and focused on open aortic procedures—with overall low certainty of evidence.⁵ More recently, an evidence map and scoping review commissioned by the Patient-Centered Outcomes Research Institute concluded that although interest in ERAS for vascular surgery is growing, implementation is inconsistent and high-quality outcome data are sparse, particularly for endovascular and hybrid procedures.⁶ These reviews highlight the need not only for more robust clinical outcome trials but also for implementation research that examines how ERAS principles are enacted in daily practice and how education and organisational support shape adherence.

The imperative to optimise perioperative care is particularly acute in vascular surgery because the patient population is ageing and often frail. Frailty is highly prevalent among patients undergoing open abdominal aortic aneurysm repair, endovascular aneurysm repair and lower extremity revascularisation, and is consistently associated with higher mortality, longer length of stay, increased complications and non-home discharge.⁷ Meta-analyses demonstrate that frail vascular patients have roughly two- to three-fold higher odds of adverse outcomes compared with non-frail peers, independent of chronological age and comorbidity burden.⁷ At the same time, international geriatric surgery initiatives, including the American College of Surgeons Geriatric Surgery Verification (GSV) programme and best-practice guidelines from surgical and geriatric societies, call for routine frailty screening, goal-concordant care, proactive delirium prevention and attention to functional status and transitions of care in older surgical patients.

Postoperative delirium and functional decline are particularly relevant geriatric outcomes for older vascular patients. Systematic reviews indicate that delirium occurs in 5–39% of patients after major vascular surgery, with the highest incidence after open aortic procedures and surgery for critical limb ischaemia.⁸ Advanced age, pre-existing cognitive impairment, functional dependence and emergency or high-risk vascular procedures are consistent risk factors, and delirium is associated with increased mortality, institutionalisation and long-term cognitive decline.⁸ Many ERAS and geriatric surgery standards therefore include explicit recommendations for delirium risk stratification, structured screening, non-pharmacological prevention bundles and early mobilisation, which are predominantly nursing-delivered interventions.³

Concurrently, the technological landscape of vascular surgery has shifted towards complex endovascular and hybrid procedures performed in hybrid operating rooms. Hybrid suites combine high-end imaging (fixed C-arm, CT or MRI) with full surgical capability and are now integral to endovascular aortic repair, branched and fenestrated stent-grafting and other complex cardiovascular interventions.⁹ Observational work on hybrid ORs has described multidisciplinary team composition, workflow and staff roles during endovascular aortic repairs, highlighting the need for meticulous coordination in crowded, technology-dense environments.¹⁰ However, most of this literature is technical and organisational; it provides limited insight into how the hybrid environment affects perioperative nursing care for frail older adults or the feasibility of implementing geriatric-focused ERAS elements, such as early mobilisation and frequent reorientation, when access to the patient may be physically constrained.

Within ERAS programmes generally, nurses are repeatedly described as “at the centre” of successful implementation.² Their responsibilities span preoperative education and optimisation, holistic assessment, intraoperative temperature and fluid management, early mobilisation, delirium prevention, pain control and discharge preparation.¹¹

Dedicated ERAS nurse roles have been recommended to coordinate pathways, collect audit data and support patients throughout the surgical journey.¹² A growing body of research has examined nurses' knowledge, attitudes and practices regarding ERAS in non-vascular specialties, including paediatric surgery, colorectal surgery, thoracic surgery and orthopaedics, and has identified gaps between positive attitudes and suboptimal day-to-day practice.¹³ Surveys and qualitative studies from Europe, Australia and Asia have reported common barriers such as limited staffing, competing workload, inadequate training, lack of standardised protocols and variable support from physicians and managers.¹⁴ Collectively, these studies suggest that educational interventions and organisational support are critical to translating ERAS principles into routine nursing care.

Notably, ERAS implementation from a nursing perspective has been only sparsely studied in vascular surgery. The Apaydin evidence map and prior systematic reviews identify very few nurse-focused implementation studies and note that most vascular ERAS publications do not report how nursing care processes were organised or supported.⁶ To our knowledge, no multicentre survey has specifically examined perioperative nurses' implementation of geriatric-focused ERAS elements—such as frailty assessment, delirium screening and prevention, early mobilisation and transitional care—for older adults undergoing open or hybrid aortic surgery. This gap is particularly salient in China, where ERAS programmes have expanded rapidly across multiple surgical specialties and several recent studies have demonstrated the benefits of ERAS-based nursing interventions. Nevertheless, published work from China has focused mainly on specialty-specific clinical outcomes rather than on how nurses implement, adapt and sustain vascular ERAS processes in routine care.¹⁵ The maturity of ERAS pathways, access to geriatric support, and organisational capacity for implementation may therefore differ substantially between hospitals.

Understanding the extent to which perioperative nurses implement ERAS-consistent and geriatric-focused practices in real-world vascular settings, and the factors that facilitate or hinder this implementation, is essential for designing effective education, staffing models and quality-improvement strategies. Existing clinical guidelines for open aortic and lower extremity vascular surgery articulate what should be done, but there is limited empirical information on how and how often core elements such as preoperative education, frailty assessment, delirium prevention, early mobilisation and structured discharge planning are delivered to older vascular patients in routine practice, especially in hybrid OR-based pathways.³

The present study addresses this gap by conducting a multicentre cross-sectional survey of perioperative nurses in eight tertiary general hospitals in Shanxi Province, China. Drawing explicitly on the ERAS/SVS consensus statement for open aortic vascular surgery and the framework for lower extremity bypass, we developed a nurse-focused questionnaire that maps guideline recommendations onto concrete nursing practices across the perioperative pathway, with particular attention to geriatric-focused elements.³ Our objectives were to: (1) describe nurses' self-reported implementation of ERAS-consistent and geriatric-focused practices for older adults undergoing open and hybrid aortic procedures; (2) examine variation in implementation by unit type, training and organisational context; (3) identify independent nurse- and hospital-level factors associated with higher implementation; and (4) explore perceived barriers and facilitators to delivering geriatric-focused ERAS care. By focusing on the nursing contribution in a high-risk, frail surgical population and in technologically complex hybrid OR environments, this study seeks to generate actionable insights for strengthening ERAS pathways, nurse education and geriatric perioperative care in vascular surgery, both in China and internationally.

Methods

Study Design

This study employed a multicentre, cross-sectional survey design to investigate the implementation of geriatric-focused Enhanced Recovery After Surgery (ERAS) nursing practices among perioperative nurses caring for older adults undergoing major aortic vascular surgery. The study protocol adhered to the recommended guidance for observational studies as outlined in the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement and, where relevant, the Checklist for Reporting Results of Internet E-Surveys (CHERRIES).^{16,17} The study was conceptually informed by a Donabedian structure–process–outcome framework. In this model, hospital and unit characteristics (structure) are hypothesised to influence nurse-delivered ERAS practices (process), which are ultimately expected to affect patient outcomes, although patient-level outcomes were not directly measured in this survey. To further operationalise the determinants of

nursing practice, we drew on a capability–opportunity–motivation perspective on behaviour change: capability was assessed through ERAS and geriatric training; opportunity through staffing, time, and environmental factors; and motivation through attitudes towards ERAS in older and frail patients. As a cross-sectional implementation study, the design was intended to describe current practice and explore associated factors rather than establish causal effects.

As summarised in [Figure 1](#), the overall study design, setting, data collection and analysis steps are outlined below.

Setting

The study was conducted in Shanxi Province, China, across eight large general hospitals with established vascular surgery services. All participating centres were tertiary-level institutions capable of providing open aortic surgery and complex endovascular and hybrid aortic procedures, including elective open repair of abdominal aortic aneurysms, thoraco-abdominal aortic repair, and hybrid arch or thoracic endovascular aortic repair (TEVAR) with debranching. Each hospital possessed at least one dedicated vascular surgery team and access to either a dedicated hybrid operating room (OR) or a conventional operating theatre adapted for hybrid procedures.

The perioperative care pathway for older vascular patients in these centres typically spanned pre-admission or pre-anaesthesia assessment clinics, operating theatres or hybrid ORs, post-anaesthesia care units (PACU), intensive care or high-dependency units (ICU/HDU), and vascular surgical wards. At the time of the study, three hospitals had implemented a formal written ERAS pathway specifically for open aortic or major vascular surgery. The remaining five hospitals followed conventional perioperative protocols which contained some ERAS-aligned elements but lacked a unified written programme. None of the hospitals operated a dedicated geriatric surgery ward; however, two hospitals had access to a geriatric consultation service, and one was participating in an early implementation of a geriatric surgery quality initiative aligned with international recommendations.^{1,3,18}

Participants and Sampling

The target population comprised registered nurses working in perioperative areas who regularly care for older adults undergoing open or hybrid aortic vascular surgery. Eligible participants were registered nurses employed in operating theatres (including hybrid ORs), PACU, ICU/HDU, or vascular surgical wards in the eight participating hospitals. Inclusion criteria required at least six months of experience in the current clinical area and regular involvement in the care of patients aged 65 years or older. Nurses in pre-assessment clinics who were directly responsible for preoperative

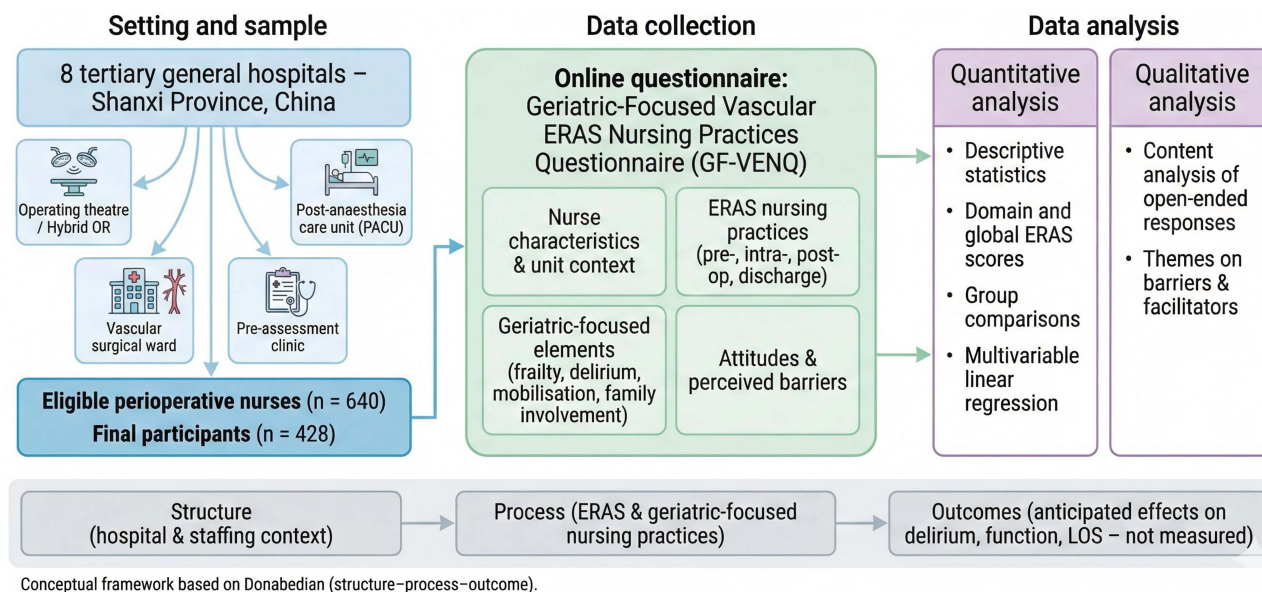


Figure 1 Study design, setting, data collection and analysis workflow for the multicentre survey. Bold headings within the figure denote the three major study components: setting and sample, data collection, and data analysis.

education and preparation were also eligible. Exclusion criteria included nurses in purely managerial or administrative roles with no regular direct patient care, agency or temporary nurses not routinely assigned to vascular units, and nurses on long-term leave during the data collection period.

A census sampling approach was employed rather than sampling a subset of staff. Within each hospital, a nurse manager or designated liaison identified all nurses who met the inclusion criteria based on staff rosters ($N = 640$). All eligible nurses were invited to participate. This approach was chosen to increase the precision of estimates and to facilitate the examination of variation between units and hospitals. While a formal a priori sample size calculation was not performed, the census strategy was expected to yield a sample size substantially larger than the 200–250 participants typically required to provide adequate power for linear regression models with 10 to 12 predictors.¹⁹ Because the survey was anonymous and identifiable roster information was not retained by the research team, individual-level characteristics of non-responders were not available for comparison.

Questionnaire Development

The survey instrument, the Geriatric-Focused Vascular ERAS Nursing Practices Questionnaire (GF-VENQ), was developed specifically for this study. Its content was derived primarily from the ERAS Society and Society for Vascular Surgery (SVS) clinical practice guidelines for perioperative care in open aortic vascular surgery and the framework for lower extremity bypass surgery.^{3,20} These guidelines provide 36 recommendations across four perioperative phases, highlighting numerous nursing-sensitive elements such as preoperative education, nutritional optimisation, mobilisation, and discharge planning. Development proceeded in two stages. First, the research team mapped relevant guideline recommendations to four perioperative phases (preadmission, preoperative, intraoperative, postoperative) and grouped them into preliminary domains. Second, geriatric-specific content was integrated based on international guidance for older surgical patients.^{1,6,18,21} This included practices such as structured frailty assessment, delirium screening, functional optimisation, and family involvement. Items were phrased as statements about usual practice (eg., “In my unit, older vascular patients are...”) or self-reported behaviours. Content validity was assessed by an expert panel of nine members, comprising two vascular surgeons, one anaesthesiologist, one geriatrician, three senior perioperative/vascular nurses, and two nurse academics. Experts rated items on a four-point scale for relevance and clarity. Items with low ratings were revised or removed, resulting in a scale-level content validity index (S-CVI) exceeding 0.90.²² Following a pilot test with 15 perioperative nurses to refine wording and assess survey length, the final questionnaire contained 58 closed questions and one open-ended question. The development process prioritised content coverage, expert review and feasibility for a new implementation-focused instrument. More extensive psychometric testing, including factor analysis and formal construct validation, was not undertaken in this initial study and should be considered in future work. An overview of questionnaire domains and example items mapped to guideline recommendations is provided in the [Supplementary Material \(Supplementary Appendix 1 and Supplementary Table S1\)](#).

Measures

The GF-VENQ comprises five distinct sections designed to capture a comprehensive picture of nursing characteristics, organizational context, and clinical practices. Sections A and B focus on background variables: Section A collects demographic and professional data, including age, gender, education, total and unit-specific nursing experience, clinical setting (eg., hybrid OR, PACU, ward), and specialist certifications. Section B assesses the unit and organizational context, covering hospital type, nurse-to-patient ratios, and the presence of formal ERAS pathways or coordinator roles. This section also operationalizes key structural predictors for analysis, specifically measuring perceived staffing adequacy on a four-point scale and assessing educational exposure via dichotomous items regarding recent ERAS-specific and geriatric/frailty training.

Section C serves as the primary measure of practice, evaluating implementation frequencies on a five-point scale ranging from “never” to “always.” This section spans five domains: preoperative education and optimisation; frailty and cognitive/delirium assessment; intraoperative and PACU practices; postoperative ward-based care; and discharge planning. Analytic scoring involves calculating mean scores for each domain, a Global ERAS Implementation Score derived from all 35 items, and a specific Geriatric-Focused ERAS Subscale extracted from relevant items such as delirium screening and tailored mobilisation. The instrument was designed to assess reported implementation of nursing practices

rather than diagnose patient risk or measure individual clinical competence. Finally, Sections D and E address the psychological and practical determinants of care. Section D measures nurses' attitudes and confidence regarding the application of ERAS to frail older adults on a five-point agreement scale, while Section E assesses potential barriers-categorized by capability, opportunity, and motivation-on a four-point scale, concluding with an open-ended enquiry into the primary challenges of delivering ERAS-consistent care.²³

Data Collection

Data collection was conducted between March and July 2024. Local nurse coordinators disseminated the survey link via work Email lists, unit WeChat groups, and printed posters with QR codes. The survey was hosted on a secure institutional platform complying with data protection regulations. The landing page provided an information sheet detailing the study purpose, voluntary nature, and anonymity; clicking the electronic consent button constituted implied informed consent.

To minimise recall bias and duplicate responses, participants confirmed they had not previously completed the survey. No personal identifiers or IP addresses were stored. Two reminder messages were sent at two-week intervals. Of the 640 eligible nurses, 452 submitted responses. To ensure data quality, questionnaires with >20% missing data on key practice items were excluded. The final analytic sample consisted of 428 responses, representing a usable response rate of 66.9%. Because the survey was anonymous, no individual-level data were available to compare respondents and non-respondents.

Data Analysis

Quantitative data were analysed using IBM SPSS Statistics version 28.0 (IBM Corp., Armonk, NY, USA). Missing data were minimal and random; thus, complete-case analysis was employed. Internal consistency for ERAS domains was assessed using Cronbach's alpha, with values >0.70 considered acceptable.²³

Descriptive statistics (means/SDs for continuous variables, counts/percentages for categorical variables) were used to summarise sample characteristics and implementation scores. Differences in ERAS scores between groups (eg., by training status, unit type, or hospital pathway) were examined using independent-samples t-tests or one-way analysis of variance (ANOVA) with post hoc tests.

Multivariable linear regression models were constructed to identify independent predictors of the Global ERAS Implementation Score. Candidate predictors were selected a priori based on the theoretical framework and included nurse characteristics (experience, education), clinical area, training (ERAS, geriatric), and organisational factors (pathway status, staffing). To avoid multicollinearity, perceived staffing adequacy was retained over raw nurse-to-patient ratios. A hierarchical modelling strategy was used, entering nurse-level variables first, followed by unit- and hospital-level variables. Assumptions of linearity, homoscedasticity, and multicollinearity were verified. Sensitivity analyses using robust standard errors clustered at the hospital level were conducted to account for potential site-level clustering effects. Statistical significance was set at $p < 0.05$. Given the observational design, residual confounding from unmeasured contextual factors such as unit culture, local leadership support, interdisciplinary coordination, or patient case-mix could not be excluded.

Qualitative responses to the open-ended question were analysed using inductive qualitative content analysis.²⁴ Two researchers independently coded meaning units line-by-line, following the phases of familiarisation, coding, and theme development described by Braun and Clarke.²⁵ Codes were grouped into categories and themes reflecting structural, organisational, and individual barriers.

Ethical Considerations

The study was approved by the Research Ethics Committee of the lead university in Shanxi Province and the institutional review boards of all participating hospitals. Participation was strictly voluntary. The study design ensured participant anonymity and minimal risk of harm, in accordance with the ethical principles of the Declaration of Helsinki and relevant national regulations on human research.

Results

Participant Characteristics

A total of 452 nurses accessed the online questionnaire during the data collection period. After exclusion of 24 questionnaires with more than 20% missing data on ERAS practice items, 428 responses from eight tertiary general hospitals in Shanxi Province were included in the analysis. This corresponds to a usable response rate of 66.9% of the 640 eligible perioperative and vascular nurses identified from staffing rosters. Because no personal identifiers were retained, the characteristics of non-responders could not be examined.

Participants' demographic and professional characteristics are summarised in [Table 1](#). The mean age of respondents was 33.8 years (standard deviation [SD] 6.9), and most were women (91.6%). The median duration of nursing experience was 9.0 years (interquartile range 5–14), and the median time in the current clinical area was 6.0 years (interquartile range 3–10). The majority of nurses (68.0%) held a bachelor's degree in nursing, 14.7% held a master's degree, and 17.3% reported a diploma or associate degree as their highest qualification. Approximately one quarter (24.8%) reported holding a specialist certification in perioperative, critical care or vascular nursing.

Nurses were drawn from across the perioperative pathway. Just under one third worked primarily in operating theatres or hybrid operating rooms (29.7%), 15.0% in post-anaesthesia care units, 20.3% in intensive care or high-dependency units, 30.1% on vascular surgical wards, and 4.9% in pre-assessment clinics. In terms of training, 45.8% of participants reported having received specific ERAS-related education in the last two years, and 31.5% reported formal training related to geriatric, frailty or delirium care. Slightly more than half of the sample (57.9%) were employed in hospitals that had implemented a formal written ERAS pathway for open aortic or major vascular surgery, and 30.1% worked in hospitals with access to a geriatric consultation service. Self-reported nurse-to-patient ratios varied across units; 26.4% of nurses reported ratios of one nurse to two or fewer patients on their main shift, 40.9% reported ratios of one to three or one to four, and 32.7% reported ratios of one to five or more. Perceived staffing adequacy, assessed on a four-point scale

Table 1 Demographic and Professional Characteristics of Participating Nurses (N = 428)

Characteristic	n (%) or mean \pm SD/median (IQR)
Age, years, mean \pm SD	33.8 \pm 6.9
Female	392 (91.6)
Total nursing experience, years, median (IQR)	9.0 (5–14)
Experience in current area, years, median (IQR)	6.0 (3–10)
Highest nursing qualification	
– Diploma/associate degree	74 (17.3)
– Bachelor's degree	291 (68.0)
– Master's degree or above	63 (14.7)
Specialist certification (perioperative/critical care/vascular)	106 (24.8)
Primary clinical area	
– Operating theatre/hybrid operating room	127 (29.7)
– Post-anaesthesia care unit	64 (15.0)
– ICU/high-dependency unit	87 (20.3)
– Vascular surgical ward	129 (30.1)
– Pre-assessment/pre-anaesthesia clinic	21 (4.9)
ERAS-specific training in last 2 years	196 (45.8)
Geriatric/frailty/delirium training	135 (31.5)
Hospital with formal vascular ERAS pathway	248 (57.9)
Hospital with geriatric consultation service	129 (30.1)
Nurse-to-patient ratio on main shift	
– \leq 1:2	113 (26.4)
– 1:3–1:4	175 (40.9)
– \geq 1:5	140 (32.7)

Table 2 ERAS Nursing Practice Domain Scores and Internal Consistency (N = 428)

Domain	Number of Items	Mean \pm SD (1–5)	Cronbach's α
Preoperative education and optimisation	8	3.63 \pm 0.72	0.83
Frailty and cognitive/delirium assessment	7	2.71 \pm 0.81	0.79
Intraoperative and PACU practices	6	3.82 \pm 0.61	0.84
Postoperative ward-based care	10	3.47 \pm 0.68	0.88
Discharge planning and transitional care	4	3.23 \pm 0.79	0.80
Geriatric focused ERAS subscale	5	2.88 \pm 0.73	0.86
Global ERAS implementation score (all items)	35	3.41 \pm 0.49	0.91

from “very inadequate” to “very adequate”, varied across settings and was used in regression analyses as a summary indicator of staffing conditions.

Implementation of ERAS Nursing Practices

Scale scores for ERAS nursing practice domains and the geriatric-focused ERAS subscale are presented in Table 2. The global ERAS implementation score, calculated as the mean of all 35 practice items, had an overall mean of 3.41 (SD 0.49) on the five-point frequency scale, corresponding to practices being implemented between “sometimes” and “often”. Among the individual domains, the highest mean scores were observed for intraoperative and post-anaesthesia care unit practices (mean 3.82, SD 0.61) and for preoperative education and optimisation (mean 3.63, SD 0.72). Postoperative ward-based care practices had a mean score of 3.47 (SD 0.68), and discharge planning and transitional care had a mean of 3.23 (SD 0.79). Frailty and cognitive/delirium risk assessment practices had the lowest mean score, at 2.71 (SD 0.81), indicating relatively infrequent implementation. The geriatric-focused ERAS subscale, comprising items on frailty assessment, delirium screening and prevention, tailored mobilisation and involvement of family caregivers, showed a mean score of 2.88 (SD 0.73). Internal consistency reliability was acceptable to excellent across domains, with Cronbach's alpha values ranging from 0.79 for frailty and cognitive assessment to 0.88 for postoperative ward-based care. Figure 2 visualises relative strengths and gaps across domains.

To provide further insight into specific practices, Table 3 presents the proportion of nurses reporting that selected key behaviours were carried out “often” or “always” for older patients undergoing open or hybrid aortic surgery.

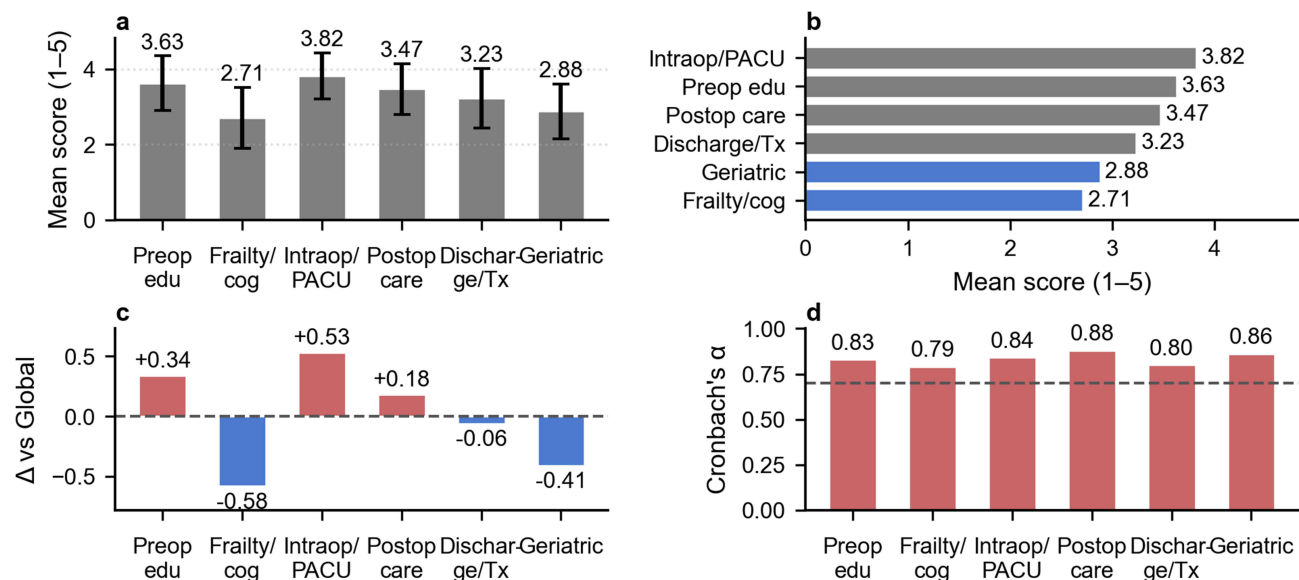


Figure 2 ERAS implementation scores by domain and geriatric-focused subscale. Subpart (a) shows mean implementation scores across domains on the 1–5 scale with error bars indicating variability; subpart (b) shows ranked mean domain scores; subpart (c) shows each domain's deviation from the global ERAS score; and subpart (d) shows Cronbach's alpha coefficients for each domain.

Approximately two-thirds of respondents (67.8%) reported that structured written and verbal preoperative information was often or always provided. In contrast, only 23.4% indicated that older vascular patients were routinely assessed for frailty using a formal tool or documented clinical judgement, and 30.8% reported using a structured delirium screening tool such as the Confusion Assessment Method each shift in the postoperative period. Early mobilisation appeared better established: 75.5% of nurses reported that medically stable patients were encouraged to sit out of bed and begin walking on the first postoperative day. Early oral intake, defined as resumption of oral fluids or diet on the day of surgery or first postoperative day according to protocol, was reported as often or always implemented by 62.1% of respondents. A clear majority (70.6%) indicated that structured discharge education covering wound care, medication adherence and warning signs was routinely provided, and 57.7% reported frequent involvement of family caregivers in postoperative education and planning. Tailoring mobilisation goals and discharge planning specifically for frail or cognitively impaired patients was reported as often or always by 48.6% of respondents.

ERAS Implementation by Unit Type, Training and Hospital Context

ERAS implementation varied significantly across unit types, training status and hospital context, as summarised in Table 4. Nurses working in pre-assessment clinics reported the highest global ERAS implementation scores (mean 3.68, SD 0.43), followed by those on vascular wards (mean 3.49, SD 0.47) and in ICU/HDU (mean 3.44, SD 0.50). Nurses in operating theatres or hybrid operating rooms had slightly lower global scores (mean 3.32, SD 0.49), although their

Table 3 Frequency of Selected ERAS and Geriatric-focused Nursing Practices

Practice Item (Abbreviated)	“Often/Always” n (%)
Provide structured verbal and written preoperative information	290 (67.8)
Perform routine preoperative frailty assessment (formal tool or documented judgement)	100 (23.4)
Use structured delirium screening tool postoperatively (e.g. CAM)	132 (30.8)
Encourage sit-out-of-bed and walking on postoperative day 1	323 (75.5)
Support early oral intake according to protocol (day of surgery or POD1)	266 (62.1)
Provide structured discharge education to patients and family	302 (70.6)
Involve family caregivers in postoperative education and planning	247 (57.7)
Tailor mobilisation and discharge plans for frail or cognitively impaired older patients	208 (48.6)

Table 4 Global ERAS Implementation Scores by Unit Type, Training and Hospital ERAS Status

Group	n	Global ERAS Score, Mean \pm SD	p-value
Unit type			
Operating theatre/hybrid OR	127	3.32 \pm 0.49	
Post-anaesthesia care unit	64	3.38 \pm 0.48	
ICU/high-dependency unit	87	3.44 \pm 0.50	
Vascular surgical ward	129	3.49 \pm 0.47	
Pre-assessment/pre-anaesthesia clinic	21	3.68 \pm 0.43	0.002a
ERAS-specific training			
Yes	196	3.61 \pm 0.45	
No	232	3.26 \pm 0.47	<0.001b
Geriatric/frailty/delirium training			
Yes	135	3.55 \pm 0.45	
No	293	3.34 \pm 0.50	<0.001b
Hospital has formal ERAS pathway			
Yes	248	3.58 \pm 0.44	
No	180	3.18 \pm 0.48	<0.001b

Note: ^ap value from one-way ANOVA across unit types. ^bp value from independent-samples t-test.

intraoperative and PACU domain scores were high while scores for discharge and transitional care were understandably lower. Differences in the global score across unit types were statistically significant ($F[4, 423] = 4.21, p = 0.002$). Post-hoc comparisons indicated that nurses in pre-assessment clinics and vascular wards had significantly higher global implementation scores than those in operating theatres or hybrid operating rooms.

Nurses who had received ERAS-specific training reported significantly higher global ERAS implementation scores compared with those without such training (mean 3.61, SD 0.45 vs. 3.26, SD 0.47; $t[426] = 8.54, p < 0.001$). A similar pattern was observed for the geriatric-focused ERAS subscale (mean 3.08, SD 0.70 vs. 2.71, SD 0.72; $t[426] = 5.31, p < 0.001$). Geriatric or frailty training was also associated with higher scores: nurses with geriatric training had a mean global ERAS score of 3.55 (SD 0.45), compared with 3.34 (SD 0.50) among those without ($t[426] = 4.32, p < 0.001$).

At the hospital level, the presence of a formal written ERAS pathway for open aortic or major vascular surgery was strongly associated with higher reported implementation. Nurses working in hospitals with an ERAS pathway had a mean global score of 3.58 (SD 0.44), compared with 3.18 (SD 0.48) in hospitals without a pathway ($t[426] = 9.23, p < 0.001$). Differences were particularly marked for preoperative education and optimisation, frailty and cognitive assessment, and discharge planning domains. These contrasts are visualised in [Figure 3](#).

Predictors of ERAS Implementation

[Table 5](#) presents the results of the multivariable linear regression analysis examining independent predictors of the global ERAS implementation score. The overall model was statistically significant ($F[9, 418] = 28.4, p < 0.001$) and explained 38% of the variance in global ERAS scores (adjusted $R^2 = 0.38$). After adjustment for other variables in the model, ERAS-specific training, hospital ERAS pathway status, geriatric training and perceived staffing adequacy emerged as significant positive predictors. A substantial proportion of variance remained unexplained, consistent with the likely contribution of other unmeasured contextual influences such as team culture, leadership engagement, case-mix and interdisciplinary coordination.

Nurses who had received ERAS-specific training scored on average 0.28 points higher on the global ERAS scale (unstandardised coefficient $B = 0.28$, 95% confidence interval [CI] 0.19–0.36, $p < 0.001$) compared with those without training. Working in a hospital with a formal ERAS pathway was associated with a 0.24-point higher global score ($B = 0.24$, 95% CI 0.15–0.33, $p < 0.001$). Geriatric or frailty training was also independently associated with higher implementation ($B = 0.12$, 95% CI 0.03–0.21, $p = 0.008$). Each one-point increase on the four-point perceived staffing adequacy scale (from “very inadequate” to “very adequate”) was associated with a 0.09-point increase in global ERAS score ($B = 0.09$, 95% CI 0.03–0.15, $p = 0.004$). Years of nursing experience, modelled per five-year increment, had a small but significant positive effect ($B = 0.04$, 95% CI 0.01–0.07, $p = 0.012$). Education level and unit type were not

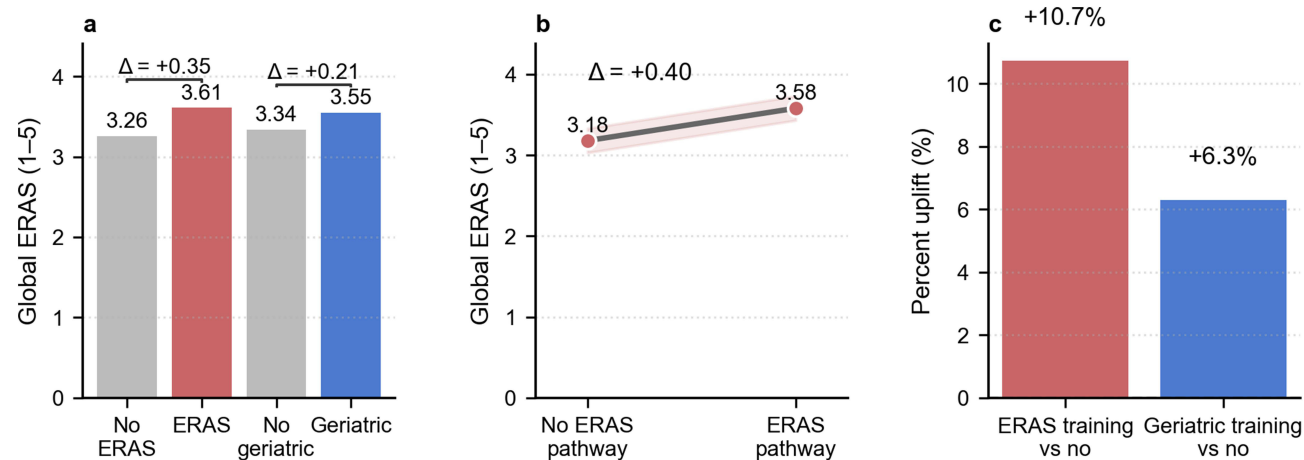


Figure 3 Global ERAS implementation scores by ERAS training and by hospital ERAS pathway status. Subpart (a) compares mean global ERAS scores by ERAS-specific training and geriatric training status; subpart (b) compares mean global ERAS scores by hospital ERAS pathway status; and subpart (c) shows the percent uplift associated with ERAS training and geriatric training.

Table 5 Multivariable Linear Regression Model for Global ERAS Implementation Score (N = 428)

Predictor	B (Unstandardised)	95% CI	p-value
Intercept	2.96	2.73 to 3.19	<0.001
Years of nursing experience (per 5 years)	0.04	0.01 to 0.07	0.012
Bachelor's degree vs. diploma	0.09	-0.02 to 0.20	0.112
Master's degree vs. diploma	0.13	-0.01 to 0.27	0.073
ERAS-specific training (yes vs. no)	0.28	0.19 to 0.36	<0.001
Geriatric/frailty training (yes vs. no)	0.12	0.03 to 0.21	0.008
Hospital with ERAS pathway (yes vs. no)	0.24	0.15 to 0.33	<0.001
Perceived staffing adequacy (1–4)	0.09	0.03 to 0.15	0.004
ICU/HDU vs. operating theatre	0.05	-0.05 to 0.15	0.326
Ward vs. operating theatre	0.09	-0.01 to 0.19	0.082
Pre-assessment clinic vs. operating theatre	0.21	0.04 to 0.38	0.015

significant predictors in the fully adjusted model, although nurses in pre-assessment clinics tended to have higher scores compared with those in operating theatres.

ICU, intensive care unit; HDU, high-dependency unit. Reference categories are diploma for education, no training, no ERAS pathway, and operating theatre for unit type.

Sensitivity analyses using robust standard errors clustered by hospital yielded similar estimates and did not alter the pattern of statistically significant predictors, suggesting that clustering at hospital level did not substantially bias the results.

Perceived Barriers and Facilitators

Quantitative ratings of potential barriers and facilitators are summarised in Table 6. Among the structural and organisational factors, inadequate nurse staffing and high workload were the most prominent barriers. Nearly two thirds of nurses (63.3%) rated limited staffing as a “major barrier” to implementing early mobilisation and other ERAS elements, with a mean barrier score of 3.12 (SD 0.79) on the four-point scale. Time pressure and competing task demands were rated as a major barrier by 57.7% of respondents (mean 2.96, SD 0.81). Approximately 43.7% of nurses considered lack of geriatric-specific knowledge and training to be a major barrier (mean 2.78, SD 0.85), and 37.9% cited the absence of a clear, written ERAS protocol for vascular surgery in their hospital as a major barrier (mean 2.64, SD 0.90). Limited access to physiotherapy and dietetics services for older vascular patients was rated as a major barrier by 34.8% of respondents. Environmental constraints associated with the physical layout of hybrid operating rooms, such as limited space and difficulty accessing patients surrounded by equipment, were rated as a major barrier by 27.3% (mean 2.41, SD 0.88). Fewer nurses identified resistance or inconsistent support from surgeons and anaesthesiologists as a major barrier (21.7%), although the mean barrier score for this item (2.29, SD 0.89) suggests it remains a non-trivial concern.

Table 6 Perceived Barriers to Implementing Geriatric-focused ERAS Nursing Practices (N = 428)

Barrier Item (Abbreviated)	Mean \pm SD (1–4) ^a	“Major barrier” n (%)
Limited nurse staffing/high workload	3.12 \pm 0.79	271 (63.3)
Time pressure and competing tasks	2.96 \pm 0.81	247 (57.7)
Lack of geriatric/frailty training	2.78 \pm 0.85	187 (43.7)
Absence of clear written ERAS protocol for vascular surgery	2.64 \pm 0.90	162 (37.9)
Limited physiotherapy/dietetics support	2.59 \pm 0.88	149 (34.8)
Physical constraints of hybrid OR environment	2.41 \pm 0.88	117 (27.3)
Resistance or inconsistent support from surgeons/anaesthesiologists	2.29 \pm 0.89	93 (21.7)
Limited educational materials for patients and families	2.21 \pm 0.86	85 (19.9)

Note: ^a1 = not a barrier, 2 = minor barrier, 3 = moderate barrier, 4 = major barrier.

Table 7 Themes from Open-Ended Responses on Challenges in Implementing Geriatric-Focused ERAS Care

Theme	Brief Description	Illustrative Quotations ^a
ERAS as an ideal rather than a daily reality	ERAS is valued but difficult to deliver consistently due to workload, staffing and competing priorities.	“We know ERAS is good, but with so many patients and limited nurses, early mobilisation and full education are the first things to be sacrificed.” (Nurse 214, ward)
Caring for frail older adults in a high-technology environment	Technical and spatial constraints of hybrid OR and ICU environments complicate holistic care of frail patients.	“In the hybrid room there are machines everywhere. It is hard even to reach the patient to comfort them, let alone mobilise them early when they are full of lines.” (Nurse 57, hybrid OR)
Fragmented responsibilities along the perioperative pathway	ERAS elements are distributed across multiple teams and units, leading to gaps and inconsistent implementation.	“Pre-op clinic, theatre, ICU, ward all have their own routines. Nobody is responsible for the whole pathway, so older patients sometimes fall through the cracks.” (Nurse 301, ICU)
Need for leadership and tailored education	Strong leadership, ERAS champions and specific training in geriatric issues are seen as essential to progress.	“If managers and surgeons really pushed ERAS and gave us training about frailty and delirium in vascular patients, we could do much better.” (Nurse 129, PACU)

Note: ^aQuotations are translated from Chinese and anonymised; nurse ID and primary unit are indicated in parentheses.

Qualitative Findings from Open-Ended Responses

A total of 316 nurses (73.8% of respondents) provided at least one free-text comment in response to the open-ended question on the main challenges in delivering ERAS-consistent, geriatric-focused care. Content analysis identified four overarching themes: “ERAS as an ideal rather than a daily reality”, “Caring for frail older adults in a high-technology environment”, “Fragmented responsibilities along the perioperative pathway” and “Need for leadership and tailored education”. These themes and illustrative quotations are presented in [Table 7](#).

The first theme, “ERAS as an ideal rather than a daily reality”, captured a recurrent perception that ERAS principles were widely endorsed in policy and education but difficult to translate into practice under conditions of high workload, limited staffing and frequent emergencies. Nurses described struggling to prioritise early mobilisation and comprehensive education when basic tasks were competing for time. The second theme, “Caring for frail older adults in a high-technology environment”, highlighted tensions between the technical demands of hybrid operating rooms and the need for close monitoring, communication and reassurance for frail patients. Several respondents described difficulties accessing patients physically when surrounded by imaging equipment and lines, and concerns about the safety of early mobilisation in the context of complex vascular access and monitoring devices.

The third theme, “Fragmented responsibilities along the perioperative pathway”, reflected nurses’ perceptions that responsibility for ERAS elements was spread across multiple teams and units, leading to inconsistency and gaps. Respondents noted that preoperative education, intraoperative management, postoperative mobilisation and discharge planning were often managed by different staff groups with limited communication, which could undermine continuity for older patients. The final theme, “Need for leadership and tailored education”, emphasised the importance of visible support from nurse managers and physicians, formal ERAS champions and practical training that addressed the specific challenges of implementing ERAS for frail, cognitively impaired and multimorbid vascular patients.

Discussion

This multicentre cross-sectional survey provides a detailed evaluation of ERAS-consistent and geriatric-focused nursing practices for older adults undergoing open and hybrid aortic vascular surgery in Shanxi Province, China. The findings reveal a landscape of moderate overall implementation, characterised by relatively high adherence to general perioperative elements—such as preoperative education and intraoperative normothermia—but significant gaps in geriatric-specific domains, particularly frailty assessment and delirium screening. The strong independent associations identified between implementation scores and modifiable structural factors (training, pathways, and staffing), coupled with qualitative insights into the challenges of high-technology environments, offer critical direction for optimising care in this high-risk population. They also provide implementation-focused evidence from a Chinese tertiary hospital context,

where ERAS principles are increasingly promoted but geriatric adaptation and pathway integration may remain uneven across institutions.

The Gap Between General ERAS and Geriatric Nuance

The mean global implementation score of 3.41 indicates that while ERAS principles are frequently applied, they are not yet universally embedded. This moderate level of adherence aligns with international benchmarks in general surgery, where compliance often hovers between 60% and 70%.²⁶ However, the disparity between the high uptake of procedural interventions and the low implementation of geriatric assessments highlights a “fidelity gap” common in complex interventions.²⁷ In the Chinese context, this pattern may also reflect the relatively rapid spread of ERAS concepts across specialties without the same degree of standardisation in geriatric assessment, interdisciplinary pathway integration and nurse training.

The limited operationalisation of frailty and delirium practices is particularly concerning given the robust evidence linking these syndromes to adverse vascular outcomes.²⁸ Only 23.4% of nurses reported routine preoperative frailty assessment, a finding that mirrors the variability seen in the UK FAVE study²⁹ and suggests that despite guideline prominence, frailty identification has not yet been systematised as a core nursing responsibility.³⁰ This gap has potential clinical consequences. When frailty is not identified early, opportunities for tailored education, nutritional optimisation, mobilisation planning, family engagement and discharge preparation may be missed in a patient group already known to have elevated risks of complications, prolonged hospitalisation and non-home discharge.^{7,28} Similarly, although postoperative delirium is a frequent complication in aortic surgery,³¹ less than one-third of respondents utilised structured screening tools (eg., CAM) routinely. Without structured screening embedded into routine documentation, delirium may be under-recognised or recognised too late for timely non-pharmacological prevention and multidisciplinary response.^{32,33} Given the established links between delirium and mortality, institutionalisation, functional decline and long-term cognitive impairment,⁸ underimplementation of these practices is not merely a protocol fidelity issue; it may also weaken risk recognition and recovery-oriented care for older vascular patients. The current data therefore suggest that vascular ERAS pathways must move beyond a generic “one-size-fits-all” model and more explicitly mandate and support geriatric safeguards.

Structural Determinants: Training, Pathways, and Staffing

The study provides quantitative validation for the Donabedian premise that structural conditions dictate process quality. The strong associations between ERAS implementation and both ERAS-specific and geriatric training support the view that knowledge and confidence are prerequisite enablers.¹³ Nurses cannot be expected to manage complex geriatric syndromes in high-acuity settings without targeted education; notably, uncertainty about roles remains a documented barrier in ERAS adoption.³⁴ In practical terms, the findings imply that education for vascular nurses should not stop at general ERAS concepts, but should include frailty recognition, delirium prevention, communication with families and adaptation of recovery goals for multimorbid older adults.

Furthermore, the presence of a formal hospital-level ERAS pathway was a powerful predictor of higher implementation scores. This corroborates evidence from lower extremity bypass programmes, where protocolisation was key to reducing length of stay and clarifying multidisciplinary expectations.^{27,35} In hospitals without such pathways, qualitative feedback indicated that ERAS was perceived more as an aspiration than an operational standard. This observation is especially relevant in health systems where ERAS adoption is progressing unevenly across hospitals, because written pathways can help convert broad policy endorsement into consistent bedside practice.

However, even with training and protocols, opportunity remains a limiting factor. Perceived staffing adequacy was a significant predictor of implementation, and “limited staffing” was the most frequently cited barrier. This echoes extensive literature identifying time pressure as the primary obstacle to labour-intensive interventions like early mobilisation [34]. If structural inputs (staffing) do not match process demands (comprehensive ERAS), nurses experience the tension described in our qualitative themes-viewing ERAS as an “ideal rather than a daily reality.”

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mobilisation.³⁴ If structural inputs (staffing) do not match process demands (comprehensive ERAS), nurses experience the tension described in our qualitative themes—viewing ERAS as an “ideal rather than a daily reality.”

The Challenge of the Hybrid Environment and Fragmentation

A unique contribution of this study is the insight into how clinical environments shape nursing practice. The finding that nurses in hybrid ORs reported lower global scores than those in pre-assessment or ward settings likely reflects the tension between “high-tech” and “high-touch” care. Literature on intensive care environments suggests that technology-dense settings can physically and cognitively displace person-centred care, making tasks like reorientation and early mobilisation difficult.³⁶ Our qualitative data reinforce this, with nurses describing the difficulty of accessing frail patients amidst imaging equipment. In tertiary Chinese centres, where hybrid procedural capacity may expand faster than formal geriatric pathway redesign, this mismatch between technological sophistication and geriatric process integration may be particularly important.

This environmental challenge is compounded by pathway fragmentation. ERAS relies on a continuum of care, yet nurses described a “siloeed” reality where responsibilities for education, mobilisation, and discharge planning were fractured across units.³⁴ The lack of a single coordinating figure means that geriatric risks identified preoperatively may not be communicated to the recovery team, leading to gaps in delirium prevention. This fragmentation supports the argument for dedicated ERAS nurse coordinators in vascular surgery to bridge the gap between technical success in the hybrid OR and holistic recovery on the ward.

Implications for Practice and Education

To strengthen vascular ERAS, practice must move beyond general adoption to the deliberate integration of geriatric elements. Practical measures include incorporating brief, validated tools (eg., the Clinical Frailty Scale) into standard nursing admission checklists and establishing “geriatric-friendly” order sets that prompt early mobilisation, delirium prevention and family involvement.³⁷ Educationally, the results advocate for curricula that merge perioperative technical skills with geriatric competencies. Training should address not only what ERAS is, but how to adapt it for patients with cognitive impairment or multimorbidity.¹³ Interprofessional simulation training specifically within the hybrid OR environment could help teams co-design workflows that accommodate both technical safety and geriatric vulnerability. At an organisational level, clearly assigned ERAS coordination roles, routine audit and feedback, and stronger integration between pre-assessment, theatre, ICU and ward teams may be particularly valuable in Chinese tertiary hospitals where pathway fragmentation remains common.

Limitations

Several limitations warrant consideration. First, the cross-sectional design precludes causal inferences regarding the impact of training, pathways or staffing on practice. Second, reliance on self-reported data may introduce social desirability bias and potentially overestimate actual adherence. Third, because the survey was anonymous, we were unable to compare respondents with non-respondents, and some degree of response bias cannot be excluded. Fourth, although the questionnaire demonstrated strong content validity, acceptable internal consistency and good feasibility, more extensive psychometric testing—such as factor analysis, construct validation and external replication—was beyond the scope of this initial study. Fifth, despite the inclusion of theoretically informed predictors and sensitivity analyses clustered by hospital, residual confounding from unmeasured factors such as unit culture, leadership support, interdisciplinary relationships and patient case-mix likely remained; this is also suggested by the proportion of unexplained variance in the regression model. Sixth, the sample, while large, was restricted to tertiary hospitals in one province, which may limit generalisability to resource-limited settings or non-tertiary institutions. Finally, this study did not link nursing practices directly to patient outcomes, which remains a critical next step for demonstrating the clinical value of nursing within vascular ERAS.

Conclusion

In this multicentre survey of perioperative nurses from eight tertiary hospitals in Shanxi Province, China, ERAS-consistent nursing practices for older adults undergoing open and hybrid aortic vascular surgery were

implemented at a moderate overall level, with relatively strong uptake of some core elements but notable gaps in key geriatric-focused domains. In particular, frailty assessment and structured delirium screening and prevention were infrequently reported, despite robust evidence that frailty and delirium are major determinants of outcomes in vascular surgery. ERAS-specific training, geriatric or frailty training, hospital-level ERAS pathways and perceived staffing adequacy were all independently associated with higher implementation, and qualitative data highlighted the challenges of delivering geriatric-sensitive care in high-pressure, technology-dense environments with fragmented responsibilities.

These findings suggest that to realise the full potential of ERAS in vascular surgery, programmes must go beyond general adoption and explicitly embed geriatric-focused nursing practices into protocols, education and resourcing. Improving these elements is clinically relevant because under-recognition of frailty and delirium risk may limit tailored perioperative management for older adults undergoing high-risk aortic procedures. Investing in structured ERAS and geriatric training for nurses, establishing formal vascular ERAS pathways that incorporate frailty and delirium care, improving staffing levels and creating clearly defined ERAS coordination roles are likely to be critical steps. Future research linking nurse-level implementation to patient outcomes and testing targeted educational and organisational interventions-such as geriatric-focused ERAS curricula, hybrid operating room simulation training and ERAS nurse coordinator roles-will be essential to build the evidence base for nursing contributions to ERAS in vascular surgery. In the meantime, the patterns identified here can guide clinicians, educators and policymakers seeking to strengthen perioperative care for the growing population of older adults undergoing complex aortic procedures in China and around the world.

Data Sharing Statement

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

This study was reviewed and approved by the Ethics Committee (Institutional Review Board) of Shanxi Provincial People's Hospital (Taiyuan, Shanxi, China) (Approval/Permit No.: 250930-2). Informed consent was obtained electronically from all participants prior to participation. All procedures were performed in accordance with relevant guidelines and regulations and adhered to the principles of the Declaration of Helsinki.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that they have no competing interests.

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