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REVIEW ARTICLE

European Society of Cardiology quality indicators for the cardiovascular pre-operative assessment and management of patients considered for non-cardiac surgery. Developed in collaboration with the European Society of Anaesthesiology and Intensive Care

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Aims To establish a set of quality indicators (QIs) for the cardiovascular (CV) assessment and management of patients undergoing non-cardiac surgery (NCS).

Methods and results The Quality Indicator Committee of the European Society of Cardiology (ESC) and European Society of Anaesthesiology and Intensive Care (ESAIC) in collaboration with Task Force members of the 2022 ESC Guidelines on CV assessment and management of patients undergoing NCS followed the ESC methodology for QI development. This included (1) identification, by constructing a conceptual framework of care, of domains of the CV assessment, and management of patients with risk factors or established cardiovascular disease (CVD) who are considered for or undergoing NCS, (2) development of candidate QIs following a systematic literature review, (3) selection of the final set of QIs using a modified Delphi method, and (4) evaluation of the feasibility of the developed QIs. In total, eight main and nine secondary QIs were selected across six domains: (1) structural framework (written policy), (2) patient education and quality of life (CV risk discussion), (3) peri-operative risk assessment (indication for diagnostic tests), (4) peri-operative risk mitigation (use of hospital therapies), (5) follow-up (post-discharge assessment), and (6) outcomes (major CV events).

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Conclusion We present the 2022 ESC/ESAIC QIs for the CV assessment and management of patients with risk factors or established CVD who are considered for or are undergoing NCS y. These indicators are supported by evidence from the literature, underpinned by expert consensus, and align with the 2022 ESC Guidelines on CV assessment and management of patients undergoing NCS.

Keywords Guidelines • Non-cardiac surgery • Pre-operative cardiac risk assessment • Pre-operative cardiac testing • Pre-operative coronary artery revascularization • Perioperative cardiac management • Anaesthesiology • Post-operative cardiac surveillance • Quality indicators • Clinical Practice Guidelines

Introduction

It is estimated that 7–11% of non-cardiac surgeries (NCSs) are associated with complications, of which almost a half is due to cardiovascular disease (CVD).[1,2] Over the coming years, increasing numbers of NCS are projected for an older[3,4] and higher-risk population—with the potential for increased early mortality and life-threatening complications, such as the development of heart failure (HF) or acute-coronary syndrome.[5] Moreover, observational studies have described variation in the assessment and management of CVD in the peri-operative period for patients undergoing NCS. As such, there is a need for tools that may standardise CVD care for patients undergoing NCS.[6]

Quality indicators (QIs) are used to evaluate the implementation of guideline-recommended interventions, improve processes of care, and capture patient outcomes.[7] In parallel with the development of its Clinical Practice Guidelines, the European Society of Cardiology (ESC) has established suites of QIs for a number of CVD conditions.[8–12] To date, there are no QIs that evaluate the quality of CVD care during the peri-operative period for patients undergoing NCS. In collaboration with the Task Force of the 2022 ESC Guidelines on cardiovascular (CV) assessment and management of patients undergoing NCS and the European Society of Anaesthesiology and Intensive Care (ESAIC), the Working Group for NCS QIs was established to develop a set of QIs for the assessment and management of CVD in adult patients undergoing NCS. The ESC anticipates that QIs will improve the implementation of guideline recommendations and therefore reduce the 'evidence-practice gap' for patients undergoing NCS.

Methods

We followed the ESC methodology for the development of QIs for the quantification of CV care and outcomes.[7] In brief, this involves (1) the identification of the key domains of the perioperative assessment and management of CVD for patients undergoing NCS by constructing a conceptual framework of care delivery, (2) the development of candidate QIs by conducting a systematic review of the literature, (3) the selection of the final set of QIs using a modified Delphi method, and (4) the evaluation of the feasibility of the developed QIs.[7] The ESC QIs include main and secondary indicators. The main indicators are those that have higher validity and feasibility as scored by the Working Group members and thus may be used for measurement across regions and over time. Both the main and secondary QIs may be used for local quality improvement activities.[7,13]

Members of the Working Group

The Working Group comprised Task Force members of the 2022 ESC Guidelines on CV assessment and management of patients undergoing NCS, ESC/ESAIC representatives, a patient representative, and international experts in peri-operative CV care, as well as members of the ESC Quality Indicator Committee. The selection of candidates is based on clinical expertise, knowledge in the development of QIs for CV care, and outcomes and in the elaboration of ESC guidelines. In collaborate ESC/ESAIC whose members first worked in a smaller group for the conduct of the systematic review and the definition of the QI. Then the potential list of candidates was shared with a wider team of expert clinicians (cardiologists and anesthesiologists) and patient representatives defined as the working group.[7] A series of virtual meetings were convened between the members of the Working Group from September 2021 until June 2022.

Target population and domains of care

The initial phase of the development process involved the identification of the 'target population' and the key domains of care. The 'target population' for whom the QIs are intended was defined as patients with established or high risk for CVD, and the key domains of care were established accordingly by constructing a conceptual illustration of the care pathway for this group of patients.[7] The target population included intermediate-risk patients defined as patients aged 65 years or older or those with risk factors for CVD, and high-risk patients defined as patients with known CVD. High-risk NCS was defined as general abdominal or intraperitoneal surgery, neurosurgery, suprainguinal and peripheral arterial surgery, thoracic surgery, and transplant surgery. Definitions were developed for each of the QIs. This included a numerator, which is the group of patients for whom the QI is delivered, and a denominator, which is the group of patients eligible for the measurement.[7] Structural QIs are designed as binary measurements evaluating the availability of services in healthcare centres or units providing NCS.

Systematic review

Search strategy

We conducted a systematic review of the published literature in accordance with the Preferred Reporting Items for Systematic Review and Meta-analyses statement.[14] We searched two online bibliographic databases: MEDLINE and Embase via OVID (Wolters Kluwer, Alphen an den Rijn, the Netherlands). The initial search strategy was developed in MEDLINE using keywords and medical subject headings terms, such as 'Adrenergic beta-Antagonists', Anticoagulants', 'Biomarkers', 'Cardiovascular Agents', 'Cardiovascular Diseases', 'Diagnostic Imaging', 'Drug Therapy', 'Evidence-Based Medicine', 'Humans', 'Hydroxymethylglutaryl-CoA Reductase Inhibitors', 'Intraoperative Complications', 'Laparoscopy', 'Myocardial Revascularization', 'Perioperative Care', 'Postoperative Complications', 'Preoperative Care', and 'Risk Assessment' (for a full list see *Table A1*). Further potential articles were identified using citation-searching and hand-searching of the references of identified articles. We only included the primary publication of randomized controlled trials and included the main publications of major trials from which our search obtained only sub-studies. We excluded systematic reviews, meta-analyses, editorials, letters, and conference proceedings. The search was restricted to English-language reports and publication dates between 01 January 2014 and 08 October 2021. The search was restricted to the period after 2014 because this year corresponds to the publication of the previous

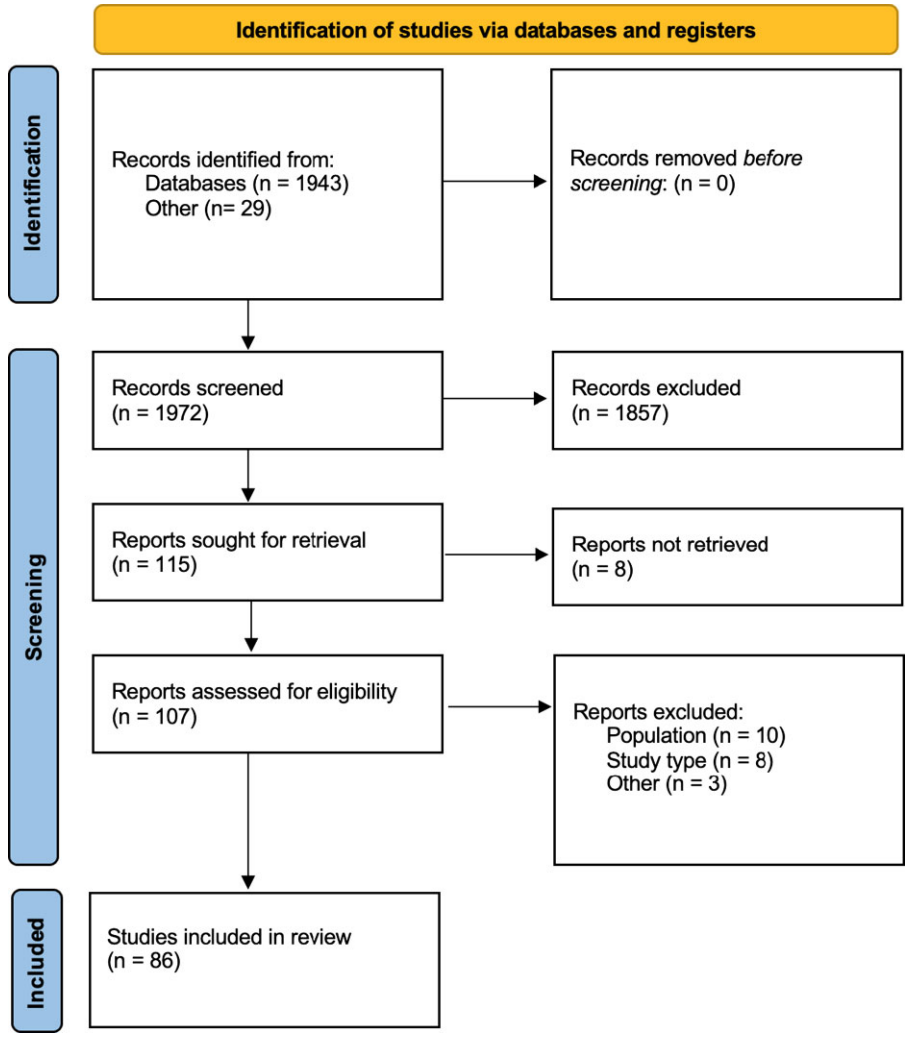

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart of systematic review.

2014 ESC Guidelines on NCS: CV assessment and management, thus ensuring current validity and applicability.[15]

Eligibility criteria

We included articles fulfiling the following criteria: (1) the study population was adults (aged ≥ 18 years) with established or with risk factors for CVD considered for or undergoing NCS, (2) the study defined an intervention (structural or process aspect of risk assessment or preventive care) for which at least one outcome measure was reported, (3) the outcome measures were hard endpoints (e.g. mortality, re-admission) or patient-reported outcomes (e.g. quality of life), (4) the study provided definitions for the intervention and outcome measure(s) evaluated, and (5) the study was a peer-reviewed randomized controlled trial or comparative clinical effectiveness study. No restriction was placed on sample sizes, but studies that reported surrogate outcomes (e.g. biomarkers) as the main endpoints were excluded.

Study selection

EndNote X9 (Clarivate Analytics, London, UK) was used for reference management and for duplicate removal. Each retrieved study was independently evaluated by three reviewers (S.A., B.G., and B.B.) against prespecified inclusion criteria. Disagreements were resolved through discussions and a full text review of the article.

Quality assessment and data extraction

Studies that met the eligibility criteria were included in the initial phase of the review. The broad inclusion was important to ensure that a list of candidate QIs was representative of a wide range of pre-operative care. For each included study, both the intervention studied and the outcome measure(s) that were evaluated were extracted. The variables were then classified according to their domain of care and to the type of the measurement (structural, process, or outcome).[7,13] Definitions of the data items extracted were also obtained when provided in the studies.

Clinical Practice Guidelines and existing QIs

We reviewed the Clinical Practice Guidelines for preoperative CV management and the assessment of the patient considered for or undergoing NCS.[15] Class I and III recommendations were then judged against the ESC selection criteria for QIs (*Table A2*). Existing QIs and relevant 'performance

measures' to NCS were also considered as candidate QIs using the same ESC QI selection criteria (*Table A3*).

Data synthesis

Modified Delphi process

The modified Delphi approach was used to evaluate the candidate QIs derived from the literature review.[7] The Working Group members were made aware of the ESC criteria for QI development (*Table A2*) to standardize the voting process, and each candidate QI was ranked by each panellist on a 9-point ordinal scale for both validity and feasibility using an online questionnaire.[7,13] In total, two rounds of voting were conducted, with a number of teleconferences after each round to discuss the results of the vote and address any concerns, questions, or ambiguities.

Voting

The 9-point ordinal scale used for voting implied that ratings of 1–3 meant that the QI is not valid/feasible; ratings of 4–6 meant that the QI is of an uncertain validity/feasible; and ratings of 7–9 meant that the QI is valid/feasible. For each candidate QI, the median and the mean deviation from the median were calculated to evaluate the central tendency and the dispersion of the votes. Indicators, with median scores $\geq$7 for validity, $\geq$4 for feasibility, and with minimal dispersion, were included in the final set of QIs.[7,13] The candidate QIs that met the inclusion criteria in the first voting round were defined as main QIs, whilst those that met the inclusion criteria after the second round of voting were defined as secondary indicators. The supporting data for voting are available from the corresponding author (BG) upon request.

Results

Domains of care

The Working Group identified six domains of care for the assessment and management of CVD peri-operatively for patients undergoing NCS. These domains aim to capture the continuum of care delivery irrespective of the healthcare institution at which the performance measurement is taking place.[16] The domains are: (1) structural framework, (2) patient education and quality of life, (3) peri-operative risk assessment, (4) peri-operative risk mitigation, (5) follow-up, and (6) outcomes (*Figure 1*).

Systematic review results

The literature search retrieved 1972 articles, of which 86 met the inclusion criteria (*Figure 2*). In total, 74 candidate QIs were extracted and subsequently included in the first Delphi round.

Modified Delphi results

Following the first round of voting, 51/74 (69%) candidate QIs were excluded. Of the remaining QIs, 8/23 (35%) met the inclusion threshold and thus were included as main QIs. The remaining 15/23 (65%) were deemed inconclusive and carried to the second voting round, after which 9/15 (60%) were included in the second Delphi round as secondary QIs.

Quality indicators

Domain 1: structural framework

This domain evaluates the characteristics of the centres that provide peri-operative care for patients with established or high risk for CVD undergoing NCS. The QIs developed in this domain may provide guidance to the allocation of resources that are needed for the delivery of optimal care. One main and no secondary QIs were selected. The main QI captures the availability of written policies for pre-operative preparation, including all of the following: fasting, investigations, blood typing, thromboprophylaxis, peri-operative diabetes management, and allergies (**Main 1.1**) for patients undergoing NCS (*Table 1*).

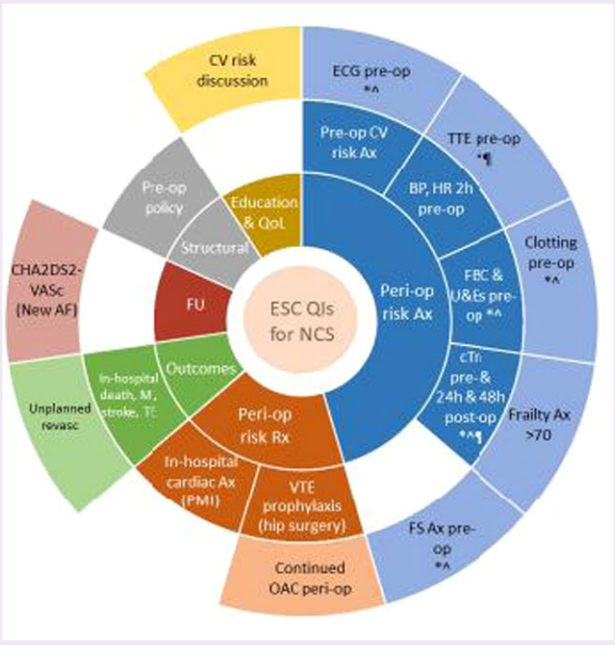

Figure 2 2022 ESC/ESAIC Quality Indicators for non-cardiac surgery: cardiovascular assessment and management.Each colour represents of on the selected domains for quality indicators (QIs): (1) structural framework (grey), (2) patient education and quality of life (yellow), (3) peri-operative risk assessment (blue), (4) peri-operative risk mitigation (orange), (5) follow-up (brown), and (6) outcomes. The internal circle defines the previous describes each of QI domains, the middle circle shows the main quality QI, and the external circle shows the secondary QIs attributed for each domain.

Abbreviations: AF, atrial fibrillation; Ax, assessment; BP, blood pressure; cTn, cardiac troponin; CV, cardiovascular; ECG, electrocardiogram; ESC, European Society of Cardiology; FBC, full blood count; FS, functional status; FU, follow up; HR, heart rate; MI, myocardial infarction; NCS, non-cardiac surgery; OAC, oral anti-coagulant; pre-op, pre-operative; peri-op, peri-operative; PMI, peri-operative myocardial infarction; QoL, quality of life; TE, thrombo-embolic events; and TTE, transthoracic echocardiogram; VTE, venous thromboembolism.

* *High-risk patients.*

^ *Intermediate-risk patients.*

¶ *High-risk non-cardiac surgeries.*

Domain 2: patient education and quality of life

Shared decision-making is an essential component of CV risk assessment for patients undergoing NCS. However, the capture of such a measure may be challenging from routine medical records. Thus, a secondary QI that evaluates the discussion with the patient about potential CV risks prior to the NCS is selected (**Secondary 2.1**) (*Table 1*).

Domain 3: peri-operative risk assessment

The evaluation of CV risks pre-operatively is the cornerstone of the assessment and management of patients undergoing NCS,

Table 1 2022 ESC/ESAIC quality indicators for the cardiovascular assessment and management on patients undergoing non-cardiac surgery

Non-cardiac surgery quality indicators (QIs)
Main QIs
Secondary QIs
Part 2. Main QIs
Domain 1. Structural framework
1 Availability of written policies for preoperative preparation, including all the following: fasting, investigations, blood typing, thromboprophylaxis, peri-operative diabetes management, and allergies
Numerator: Centres managing patients undergoing non-cardiac surgery (NCS) with written policies for pre-operative preparation, including all the following: fasting, investigations, blood typing, thromboprophylaxis, peri-operative diabetes management, and allergies
Denominator: Number of centres managing patients undergoing NCS
Domain 2. Patient education and QoL
2 Proportion of patients who have a discussion with HCP about the CV risks involved in the surgery pre-operatively
Numerator: Number of patients undergoing NCS who have a documented discussion in the medical record with HCP about the CV risks involved in the surgery pre-operatively
Denominator: Number of all patients undergoing NCS
Domain 3. Peri-operative risk assessment
3 Proportion of patients undergoing high-risk NCS who have an assessment of their cardiovascular (CV) risk
Numerator: Number of patients undergoing high-risk NCS who have an assessment of their CV risk
Denominator: Number of all patients undergoing high-risk NCS
4 Proportion of patients undergoing NCS who have their vital signs (blood pressure and heart rate) and cardiac physical examination checked pre-operatively (within 2 h)
Numerator: Number of patients undergoing NCS who have their vital signs (blood pressure and heart rate) and cardiac physical examination checked pre-operatively (within 2 h)
Denominator: Number of all patients undergoing NCS
5 Proportion of intermediate- and high-risk patients undergoing high-risk NCS who have their cardiac troponin checked pre-operatively AND at 24 and 48h after surgery
Numerator: Number of intermediate- and high-risk patients undergoing high-risk NCS who have their troponin checked pre-operatively AND at 24 and 48h after surgery
Denominator: Number of intermediate- and high-risk patients undergoing high-risk NCS
6 Proportion of intermediate- and high-risk patients undergoing NCS who have their full blood count (FBC) and renal function checked pre-operatively
Numerator: Number of intermediate- and high-risk patients undergoing NCS who have their FBC and renal function checked pre-operatively
Denominator: Number of intermediate- and high-risk patients undergoing NCS
7 Proportion of intermediate- and high-risk patients undergoing NCS who have their coagulation profile (prothrombin time, platelet count) checked pre-operatively
Numerator: Number of intermediate- and high-risk patients undergoing NCS who have their coagulation profile (prothrombin time, platelet count) checked pre-operatively
Denominator: Number of intermediate- and high-risk patients undergoing NCS
8 Proportion of intermediate- and high-risk patients undergoing NCS who have their functional status evaluated using two-flight of stairs or DASI pre-operatively
Numerator: Number of intermediate- and high-risk patients undergoing NCS who have their functional status evaluated using two-flight of stairs or DASI pre-operatively
Denominator: Number of intermediate- and high-risk patients undergoing NCS
9 Proportion of patients >70 years of age undergoing NCS who have their frailty assessed pre-operatively using a validated tool
Numerator: Number of patients >70 years of age undergoing NCS who have their frailty assessed pre-operatively using a validated tool
Denominator: Number of patients >70 years of age undergoing NCS
10 Proportion of intermediate- and high-risk patients undergoing NCS who have an ECG pre-operatively
Numerator: Number of intermediate- and high-risk patients undergoing NCS who have an ECG pre-operatively
Denominator: Number of intermediate- and high-risk patients undergoing NCS
11 Proportion of high-risk patients undergoing non-urgent high-risk NCS who have an echocardiography pre-operatively (within 3 month)
Numerator: Number of high-risk patients undergoing non-urgent high-risk NCS who have an echocardiography pre-operatively (within 3 month)
Denominator: Number of high-risk patients undergoing non-urgent high-risk NCS
Domain 4. Peri-operative risk mitigation
12 Proportion of patients undergoing high-risk orthopaedic or abdominal surgery who are prescribed VTE prophylaxis peri-operatively
Numerator: Number of patients undergoing high-risk orthopaedic or abdominal surgery (hip, knee, vertebral column, traumatism, cancer, inflammatory digestive disease, bariatric surgery, or others) who are prescribed VTE prophylaxis peri-operatively
Denominator: Number of patients undergoing hip surgery

Table 1. Continued

Non-cardiac surgery quality indicators (QIs)
13 Proportion of patients with perioperative myocardial infarction/injury (PMI) after NCS who undergo cardiac evaluation before hospital discharge
Numerator: Number of patients with PMI after NCS who undergo cardiac evaluation before hospital discharge
Denominator: Number of patients with PMI after NCS
14 Proportion of patients on anticoagulation who have their anticoagulation therapy continued peri-operatively for low-risk NCS
Numerator: Number of patients on anticoagulation who have their anticoagulation therapy continued peri-operatively for low-risk NCS
Denominator: Number of patients undergoing low-risk NCS and are on anticoagulation
Domain 5. Follow up
15 Proportion of patients undergoing NCS with NEW peri-operative AF who have their CHA_2DS_2-VASc score calculated to guide decision-making about anticoagulation
Numerator: Number of patients undergoing NCS with NEW peri-operative AF who have their CHA_2DS_2-VASc score calculated to guide decision-making about anticoagulation
Denominator: Number of patients undergoing NCS with NEW peri-operative AF
Domain 6. Outcomes
16 Proportion of patients who have any of the following CV events during hospitalization for NCS: -Death -MI -Stroke -Arterial or venous thrombo-embolic event
Numerator: Number of patients undergoing NCS who have any of the following CV events during hospitalization for NCS: Death, MI, Stroke, Arterial or venous thrombo-embolic event
Denominator: Number of all patients undergoing NCS
17 Proportion of patients who have unplanned coronary/peripheral revascularization during hospitalization for NCS
Numerator: Number of patients who have unplanned coronary/peripheral revascularization during hospitalization for NCS
Denominator: Number of all patients undergoing NCS

Abbreviations: AF, atrial fibrillation; CV, cardiovascular; ECG, electrocardiogram; ESAIC, European Society of Anesthesiology and Intensive Care; ESC, European Society of Cardiology; DASI, Duke Activity Status Index; FBC, full blood count; MI, myocardial infarction; NCS, non-cardiac surgery; PMI, peri-operative myocardial infarction; QoL, quality of life; and VTHE, venous thrombo-embolis.

particularly high-risk surgeries. The assessment of CV risk can help identify those with suboptimal risk factor control who may require treatment optimization or additional testing for stratification (**Main 3.1)**.

The recording of the pre-operative measurement of vital signs (blood pressure and heart) and cardiac physical examination within 2 h of surgery is a QI for all patients undergoing NCS (**Main 3.2**). In intermediate- and high-risk patients undergoing high-risk NCS, the documentation of troponin pre-operatively and at 24 or 48 h after surgery helps detect subclinical cardiac injury **(Main 3.3**). For intermediate- and high-risk patients undergoing all types of NCS, full blood count and renal function (**Main 3.4),** as well as coagulation profile (prothrombin time, platelet count) (**Secondary 3.1**) should be checked pre-operatively (*Table 1*). Additional pre-operative parameters have been validated in intermediate- and high-risk patients, including their functional status using two-flight of stairs or the Duke Activity Status Index (**Secondary 3.2**), a frailty assessment with a validated tool in patients aged 70 years or older (**Secondary 3.3**), a preoperative ECG (**Secondary 3.4**), and echocardiography within 3 months of surgery in high-risk patients with ongoing symptoms of HF (**Secondary 3.5**).

Domain 4: peri-operative risk mitigation

Several preventive measures have a role in reducing the perioperative CV risks in high or very high-risk patients undergoing NCS. These measures include the prescription of venous thromboembolism (VTE) prophylaxis prior to high-risk orthopaedic or abdominal surgery (hip, knee, vertebral column, traumatism, cancer, inflammatory digestive disease, bariatric surgery, or others) (**Main 4.1**), in-hospital cardiac evaluation for patients with perioperative myocardial infarction/injury after NCS (**Main 4.2**), and the continuation of long-term anticoagulation therapy peri-operatively (**Secondary 4.1**) (*Table 1*).

Domain 5: follow-up

Incident peri-operative atrial fibrillation occurs frequently in patients undergoing NCS. Stroke risk assessment (using the CHA_2DS_2-VASc score) is mandatory in patients with AF to identify an optimal stroke prevention strategy (most commonly, oral anticoagulation) (**Secondary 5.1**).

Domain 6: outcomes

Clinical outcomes following NCS are useful measures of the quality of care delivered. The Working Group selected the recording of in-hospital death, myocardial infarction, stroke, arterial or venous thrombo-embolic events as a main QI (**Main 6.1**), and the documentation of unplanned coronary/peripheral revascularization as a secondary QI (**Secondary 6.1**).

Discussion

This document presents a set of eight main and nine secondary QIs for patients undergoing NCS. These QIs have been developed using a standardized methodology and collaboratively between the Quality Indicator Committee of the ESC, members of the Task Force of the ESC/ESAIC undergoing NCS, the ESC Patient Forum, and domain experts.[7,13] The QIs presented in this document align with recommendations of the ESC/ESAIC integrate with other ESC QIs.[8,10,12] By developing QIs for patients undergoing NCS who may be at high risk for CV complications peri-operatively, it is hoped that national and international efforts may be initiated to implement these QIs

to standardize CVD assessment and management for this group of patients and reduce variation in practice.

During the process of selecting the QIs for patients undergoing NCS, we had more extensive discussions on some of the indicators. The inclusion of HF in the outcome definition was discussed by the group but not retained. This was to avoid duplication of indicators across the ESC guidelines; the ESC QIs for HF provide information about structural, process, and outcome measures for individuals with HF.[8] Also, there was consensus that a standardized definition of HF during hospitalization could be difficult to interpret and implement because HF is usually present prior to the time of surgery. The decision not to include HF in the outcome as QI does not imply that strategies to prevent and treat HF during hospitalization are not relevant.

The working group proposed that in intermediate- and high-risk patients undergoing high-risk NCS, the documentation of troponin pre-operatively and at 24 or 48 h after surgery could help detect subclinical cardiac injury. Whilst this QI may help improve stratification of CV risk as well as therapy adaptation, we acknowledge that the documentation of this QI could be a major change to current practice and potentially not be implementable in every setting. The working group was also careful to be in alignment with the wording used in the 2022 ESC/ESAIC Guidelines on NCS CV assessment and management. The continuous evaluation and reporting of structural, processes, and outcomes of healthcare are increasingly mandated by professional societies, regulators, and patients.[7,17] In recent years, QIs for CVD provided a means to benchmark performance, improve the implementation of evidence-based practice, and assess the effectiveness of quality improvement initiatives.[13] The ESC/ESAIC QIs have a role in identifying variation in CVD care quality and outcomes across regions and over time. For patients undergoing NCS, there is a lack of internationally endorsed QIs that promote standardized practice that aligns with Clinical Practice Guidelines.

Whilst previous efforts have sought to develop indicators of care quality during the peri-operative period,[18–20] these have been wide-ranging with little focus on NCS and/or associated CV complications around the time of surgery. Furthermore, there is heterogeneity in clinical practice and evidence for both under and overuse of investigations. Thus, there remains a need to standardize the assessment and management of CVD and identify groups of patients for whom non-invasive cardiac testing is appropriate.[21] The 2022 ESC/ESAIC QIs for the CV assessment and management of patients undergoing NCS define key domains of care for this group of patients and recommend specific QIs for particular subsets of patients and types of NCS.

The provision of a suite of QIs specifically designed for patients undergoing NCS may serve as a catalyst to establish regional, national, or international registries to capture real-world patient data for particular types of high-risk NCS or patient groups. The implementation of evidence-based practice needs first the assessment of potential gaps in the process of care using well-established QIs.[22] This first step is particularly important to design further interventions to overcome barriers. The knowledge-to-action cycle is a well-suited framework to illustrate the perpetual link between scientific knowledge, identification of problems, planned actions to fix, and continuing evaluation of outcomes and system sustainability.[23]

Although our work has several strengths, we acknowledge its limitations. First, we recognize that some barriers could exist for a healthcare setting to implement all the proposed QIs given the wide range of areas. Therefore, the Working Group decided not to use a composite QI because such an indicator may disadvantage centres that offer specific services or smaller hospital services, particularly in the absence of evidence about combined interventions in this clinical area. Also, the Working Group emphasized that efforts are needed to achieve performance through the integration of coordinated systems with enough granularities in the data, such as electronic healthcare records, clinical registries, and quality improvement projects.[24] Second, the selection of the final set of QIs was underpinned by expert opinions. However, the procedure of formulation of candidate QIs was based on a systematic review of the literature, and the final selection of main and secondary QIs was done after a modified Delphi method involving a range of experts including anaesthetists, surgeons, guideline Task Force members, and a patient representative. The ESC threshold criteria for validity and feasibility were applied to the results of the independent voting. Only indicators with a predefined high median score and minimal dispersion were selected in the final set of QIs. Third, the developed QIs will require updates and revisions according to the emergence of new evidence, and the feasibility of measurements needs to be evaluated continuously through registries or systems for data collection. Fourth, although were worked with a patient representative, future iterations should be more inclusive of a wider multidisciplinary membership.

Conclusion

This document defines the 2022 ESC/ESAIC QIs for the NCS, which have been developed in collaboration in collaboration with the members of the Task Force of the 2022 ESC/ESAIC NCS: CV assessment and management, the ESC Patient Forum, and the Quality Indicator Committee. In total, eight main and nine secondary QIs have been defined across six key domains of NCS. The proposed set of indicators may facilitate the implementation of guidelines recommendations in practice and provide a means to gather information about the quality of care in patients undergoing NCS.

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Data availability statement

No new data were generated or analysed in support of this research.

Appendix

Table A1 Systematic review search strategy

Database: Ovid MEDLINE(R) ALL <1946 to 08 October 2021>

Search strategy:

1 (non?cardiac adj5 (surger* or operation)).mp. (2885)

2 (vascular adj5 (surger* or intervention)).mp. (20772)

3 (aortic or major or open or (vascular adj5 surger*)).ti,ab,kf. (2247474)

4 (aneurysm adj5 (surger* or repair or intervention)).mp. (17706)

5 ((limb or peripheral) adj5 (surger* or revasculari#ation or amputation or thromboembolectomy or angioplasty)).ti,ab,kf. (17120)

6 ((pancrea* or liver or ?osophag* or adrenal or lung or pulmonary or renal or kidney* or bladder) adj5 (resection or removal or surgery or transplant)).ti,ab,kf. (176116)

7 Laparoscopy/mt (35679)

8 ((intra?peritonial or abdominal) adj5 (surger* or operation)).mp. (27079)

9 ((thoracic or chest) adj5 (surger* or operation)).mp. (38143)

10 ((brain or spine or carotid or thyroid) adj5 (surger* or operation)).mp. (34352)

11 or/1–10 (2510888)

12 Cardiac surgical procedures/(56690)

13 Coronary Artery Bypass/(50783)

14 (CABG or aortic coronary bypass or aorticocoronary anastomosis or Total arterial revascularization or total arterial revascularization or Multiple arterial revascularization or multiple arterial revascularization).tw. (19316)

15 ((aortocoronary or aorta or coronary) adj2 (anastomosis or bypass or shunt or graft)).tw. (53638)

16 (internal mammary arterial anastomosis or internal mammary arterial implantation or internal mammary artery anastomosis or internal mammary artery graft or internal mammary artery implant or internal mammary artery implantation or internal mammary-coronary artery anastomosis or Coronary Internal Mammary Artery Anastomosis or myocardial revascularization or myocardial revascularization or myocardium revascularization or myocardium revascularization or transmyocardial laser revascularization or transmyocardial laser revascularization or vineberg operation).tw. (6059)

17 Cardiomyoplasty/or (cardiomyoplasty or cardiomyoplasties).tw. (991)

18 (arterial switch or atrial switch or double switch technique* or Rastelli operation or Rastelli procedure or Rastelli technique or Senning operation or Senning procedure or Jatene procedure or Jatene technique or Jatene operation or Mustard operation or Mustard repair or Mustard procedure).tw. (2983)

19 Heart Valve Prosthesis Implantation/(24628)

20 Heart Valve Prosthesis Implantation/or (heart valve prosthesis implantation or heart valve prosthesis implant).tw. (24630)

21 Cardiac valve annuloplasty/(896)

22 (Cardiac Valve Annuloplasty or Cardiac Valve Annuloplasties or Valvular Annuloplasties or Valvular Annuloplasty or Heart Valve Annuloplasty or Heart Valve Annuloplasties or Cardiac Valve Annulus Repair or Heart Valve Annulus Repair or Cardiac Valve Annular Repair or Heart Valve Annular Repair or Cardiac Valve Annular Reduction or Cardiac Valve Annulus Shortening or Cardiac Valve Annulus Reduction).tw. (10)

23 (Aortic valve repair or aortic valve replacement or aorta valve replacement or aorta valve transplantation or aortic valve transplantation or aortic valve xenotransplantation).tw. (19908)

24 Mitral valve annuloplasty/(1734)

25 ((bicuspid cardiac valve or bicuspid cardiac valvular or bicuspid heart valve or bicuspid heart valvular or bicuspid or bicuspid valve or bicuspid valvular or left atrioventricular cardiac valve or left atrioventricular heart valve or left atrioventricular valvular or mitral cardiac valve or mitral cardiac valvular or mitral heart valve or mitral heart valvular or mitral or mitral valvular) adj2 (annuloplast* or repair or replacement)).tw. (14022)

26 (tricuspid valve repair or tricuspid valve replacement or tricuspid valve transplantation).tw. (1808)

27 Arterial switch operation/(431)

28 Pericardiectomy/or (pericardiectomy or pericardiectomies or pericardectomy or pericardectomies or pericardiotomy or pericardiotomies or pericardotomy or pericardotomies).tw. (2919)

29 Heart-assist devices/(15729)

30 (heart assist device* or heart assist pump* or vascular assist device* or artificial ventricle* or ventricle assist device* or artificial heart ventricle*).tw. (390)

31 (cardiac surgery or cardiac surgical procedure* or heart surgery or heart valve surgery or heart surgical procedure* or cardiac operation* or heart operation* or cardiosurgery or myocardial resection).tw. (60446)

32 or/12–31 (212743)

33 11 not 32 (2431191)

Table A1 Continued

Database: Ovid MEDLINE(R) ALL <1946 to 08 October 2021>

34 (periprocedural or peri-procedural or procedure-related or post-procedural or postprocedural or perioperative or intraoperative or postoperative or perioperative or intra-operative or postoperative or perisurgical or intrasurgical or postsurgical or peri-surgical or intra-surgical or post-surgical or new-onset or after surger* or after non?cardiac surger*).tw. (810122)
35 exp Preoperative Care/mt (16157)
36 Intraoperative Complications/pc (7434)
37 exp Postoperative Complications/pc (101447)
38 exp Perioperative Care/mt (38666)
39 or/34–38 (889563)
40 Biomarkers, blood/(0)
41 Diagnostic Imaging/mt (14820)
42 Risk Assessment/mt (36197)
43 'Risk Evaluation and Mitigation'/(51)
44 Drug Therapy, Combination/(171139)
45 Evidence-Based Medicine/(75018)
46 Adrenergic beta-Antagonists/tu (21365)
47 beta?blocker*.mp. (1256)
48 Hydroxymethylglutaryl-CoA Reductase Inhibitors/tu (18783)
49 statin*.mp. (47435)
50 Dual Anti-Platelet Therapy/(365)
51 Anticoagulants/tu (42446)
52 anti?coagulation.ti,ab. (43953)
53 Platelet Aggregation Inhibitors/(38509)
54 Myocardial revascularization/(11432)
55 (cardiac muscle revasculari#ation or coronary revasculari#ation or heart muscle revasculari#ation or heart myocardium revasculari#ation or heart revasculari#ation).tw. (8063)
56 or/40–55 (476115)
57 39 and 56 (29999)
58 33 and 57 (6840)
59 exp cohort studies/(2221460)
60 cohort$.tw. (697617)
61 controlled clinical trial.pt. (94451)
62 exp case-control studies/(1232119)
63 (case$ and control$).tw. (542193)
64 Randomized controlled trial.pt. (545922)
65 controlled clinical trial.pt. (94451)
66 randomized.ab. (536566)
67 placebo.ab. (222115)
68 drug therapy.fs. (2383926)
69 randomly.ab. (367415)
70 trial.ab. (571260)
71 groups.ab. (2256636)
72 or/59–71 (7219459)
73 exp animals/not humans.sh. (4896287)
74 72 not 73 (6501204)
75 (exp Child/or Adolescent/or exp Infant/) not exp Adult/(1980961)
76 conference abstract/(0)
77 75 or 76 (1980961)
78 74 not 77 (5875651)
79 58 and 78 (4551)
80 limit 79 to english language (4185)
81 limit 80 to yr="2014 -Current" (1943)

Table A2 Criteria for the development and evaluation of the ESC quality indicators for cardiovascular disease

Domain	Criteria
Importance	QI reflects a clinical area that is of high importance (e.g. common, major cause for morbidity, mortality, and/or health-related quality of life)
	QI relates to an area where there is gap in care delivery and/or variation in practice
	QI implementation will lead to a meaningful improvement in patient outcomes
	QI may address under- and/or over-use of a test or treatment
Evidence base	QI is derived from a clearly defined, acceptable evidence consistent with contemporary knowledge
	QI aligns with the respective ESC Clinical Practice Guideline recommendations.
Specification	QI has clearly defined patient group to whom the measurement applies (denominator), including explicit eligibility criteria
	QI has clearly defined patient group for whom the QI is met (numerator), including explicit definition of QI meeting criteria
	QI has a minimum population level
Validity	QI is able to correctly assess what it is intended to, adequately distinguishes between good- and poor-quality care, and compliance with the indicator would confer health benefits
Reliability	QI is reproducible even when data are extracted by different people and estimates of performance on the basis of available data are likely to be reliable and unbiased
Feasibility	QI may be identified and implemented with reasonable cost and effort
	Data needed for the assessment are (or should be) readily available and easily extracted within an acceptable time frame
Interpretability	QI is interpretable by healthcare providers, so that practitioners can understand the results of the assessment and take actions accordingly
Actionability	QI is influential to the current practice where a large proportion of the determinants of adherence to the QI are under the control of healthcare providers being assessed
	This influence of QIs on behaviour will likely improve care delivery
	QI is unlikely to cause negative unintended consequences

Table A3 Development of previous publications on quality indicator

Article title	Journal	Year	Number of indicators
Perioperative structure and process quality and safety indicators: a systematic review	British Journal of Anaesthesia, Volume 120, Issue 1, January 2018, Pages 51–66	2018	112 structure indicators 149 process indicators
Systematic review and consensus definitions for the Standardised Endpoints in Perioperative Medicine initiative: clinical indicators	British Journal of Anaesthesia, Volume 123, Issue 2, August 2019, Pages 228–237	2019	

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