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Original Contribution

Preoperative test requests for elective surgeries of different complexity: Appropriateness and interhospital variability

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HIGHLIGHTS

- Preoperative test request inappropriateness according to hospital protocols is high.
- Inappropriateness is especially high according to more restrictive NICE guidelines.
- Inappropriateness was determined by patient characteristics, surgical risk, and hospital-level factors.
- Inappropriateness has a moderate heterogeneity across centers.
- Interhospital variability may be due to differing preoperative test request criteria.

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ABSTRACT

Background: Numerous studies have questioned the usefulness of routine preoperative tests, and several guidelines have published recommendations aimed at reducing unnecessary preoperative testing.
Study objectives: To analyze the appropriateness of preoperative test requests and interhospital variability in criteria for requesting preoperative tests.
Design: Cross-sectional retrospective multicenter observational study.
Setting: Nine Spanish National Health System hospitals.
Patients: Patients over 18 years of age undergoing elective cataract surgery, inguinal hernia, laparoscopic cholecystectomy, colon surgery or primary knee replacement, in any department of the participating hospitals during 5 working days in June 2022 (n = 1522).
Exposure: Hospitals where patients underwent surgery.
Measurements: Appropriateness of requested preoperative tests according to hospital protocols and NICE guidelines analyzed with random-intercept multilevel models considering hospital-level and patient-level variables. Hospital protocol score to determine disagreement with the NICE guidelines.
Main results: Preoperative test request inappropriateness was 12.03 % according to hospital protocols and 72.99 % according to the NICE guidelines. Inappropriateness was mostly due to excessive requests and differed by hospital and surgery type. Independent factors determining inappropriateness at the hospital-level were center complexity and availability of computerized preoperative request templates; at the patient-level were age, ASA grades and surgical complexity. Protocol criteria for requesting preoperative tests varied notably between hospitals, and most protocols showed low agreement with NICE recommendations, especially in terms of over-requested preoperative tests.
Conclusions: Inappropriateness of preoperative test requests was high according to hospital protocols and especially high according to the NICE guidelines. Appropriateness was determined by patient characteristics, surgical complexity, and institutional factors. Interhospital variability in inappropriateness was explained by differing criteria for preoperative test requests.

1. Introduction

Preoperative evaluation is a standard part of clinical-surgical practice [1]. While various arguments attempt to justify routine preoperative testing – e.g., identify abnormalities in preoperative examinations that could influence complications, establish baseline values for perioperative monitoring and modification, or prevent medical-legal issues – numerous studies question their value, with 70 %–90 % of blood tests considered unwarranted and under 5 % of tests yielding abnormal results that do not influence anesthetic management of the patient or surgery outcome [2]. Unjustified routine preoperative tests do not predict adverse events during or after surgery, can generate false positives that require new or repeated tests (sometimes of an invasive nature), and may require potentially unnecessary consultations that lead to a care cascade [3–5]. The outcomes are additional delays in interventions, prolonged hospital stays, patient inconvenience (confusion, anxiety, radiation exposure, further appointments impacting the patient's personal and work life), and increased healthcare costs [6].

The number of elective surgeries performed within healthcare systems is high and increasing; as one example, the British National Health Service (NHS) performed 10.6 million such procedures in 2012–2013, an increase of 60 % over 2002–2003. Consequently, a large number of patients are affected, even when only a small percentage of tests is unnecessary [7]. Furthermore, even though tests may be inexpensive at the individual level, overall, they represent a significant economic and social burden. Multiple studies have quantified the economic impact of unnecessary preoperative testing and the subsequent care cascade triggered due to incidental findings [8–10]. In the USA, for example, unnecessary preoperative tests are estimated to annually cost USD 18 billion [3], while an economic analysis of preoperative testing of asymptomatic patients, performed in the Basque Country (Spain) in 1993, estimated that around EUR 1.9 million could be freed up from the healthcare budget for 1994 [11]. Another study of requests for preoperative tests for major outpatient surgery in a Spanish university general hospital reported that non-adherence to established protocols resulted in an estimated annual excess cost of EUR 69,337–84,727 for the hospital [12].

Several published guidelines, issued by scientific societies and anesthesiology working groups, contain evidence-based recommendations regarding routine preoperative testing in patients undergoing elective surgery [7,13–15]. Such guidelines aim to facilitate decision-making, reduce unnecessary preoperative testing, advise on which tests are warranted, and reduce variability in preoperative test requests. Nevertheless, despite the existence of guidelines and evidence of the low value of preoperative tests, doctors continue to perform them inappropriately [16]. The reasons – unclear but apparently multifactorial – include a widespread misconception that medical screening cannot be harmful, litigation fears, concerns about surgical delays, the complex healthcare environment, and the difficulty of changing ingrained habits [2,3].

The objectives of this study were (i) to analyze the appropriateness of requests for preoperative tests in patients undergoing scheduled surgical interventions of varying complexities, and (ii) to analyze interhospital variability in criteria for requesting preoperative tests. The appropriateness of preoperative test requests was evaluated according to hospital internal protocols and, using as a standard, the National Institute for Health and Care Excellence (NICE) guidelines on routine preoperative tests for elective surgery [7].

2. Methods

2.1. Study design and participants

A retrospective, cross-sectional, observational, multicenter study was conducted in 9 National Health System hospitals located in 3 regions of Spain (Appendix A: Supplementary Data 1). The hospitals, belonging to the MAPAC-MPC Network (Improvement of the Appropriateness of Healthcare and Clinical Practice), participated in the study on a voluntary basis. The study population included patients aged over 18 years who underwent specific elective surgical interventions in any department of the participating hospitals over 5 working days of a standard week (Monday 13 June to Friday 17 June 2022), selected consecutively until the necessary sample was recruited.

The surgical procedures studied were common surgeries of varying complexities [7] defined according to International Classification of Diseases-Tenth Revision-Clinical Modification (ICD-10-CM) codes:

cataract surgery (low-complexity); inguinal hernia surgery, laparoscopic cholecystectomy (intermediate-complexity); colon surgery for oncological and non-oncological conditions and primary knee replacement (high-complexity) (Appendix A: Supplementary Data 2). Excluded were urgent interventions, and interventions for which preoperative tests were requested during hospital admission.

The sample size was calculated for a single level analysis, and 274 patients for each of the 5 surgical procedures were estimated to be sufficient to establish 80 % preoperative test inappropriateness, for ±5 % precision, 10 % estimated replacement, and a 95 % confidence interval (CI). For each of the 9 participating hospitals, this represented 30 patients for each procedure: 150 patients per hospital (total 1350). This sample size was reassessed before starting the data analysis and ensured a sufficient number of participants per center for accurate estimation and inference using multilevel models. However, the number of centers included was somewhat limited for the estimation of variance components in multilevel analyzes [17]. When the necessary number of patients for a procedure failed to be recruited during the study week (as happened with smaller hospitals), the hospital was permitted to retrospectively extend the inclusion period until the required sample size was reached. The inclusion period, therefore, varied across hospitals depending on their recruitment process.

The study was carried out in accordance with the Declaration of Helsinki and complied with national and European regulations and guidelines on personal data protection. Ethical approval (protocol number 05–22–375-070) was granted on 7 August 2022 by the Ethics Committee for Research with Medicines of the Consorci Sanitari de Terrassa (Ctra. Torrebonica, S/N, 08227 Terrassa, Spain; chairperson Dr. Enric Garcia Restoy). The need for patient informed consent was waived, as this retrospective and observational study used secondary and anonymized data for a healthcare improvement context. Reporting guidelines as outlined in the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement were adhered to [18].

2.2. Procedures

The appropriateness of preoperative testing was assessed by an internal team composed of anesthesiologists and specialists from the MAPAC-MPC network, who evaluated the testing request from their hospital. Cases were identified using the surgical activity register of each participating hospital, and data on patient characteristics and requested preoperative tests were obtained from hospital electronic medical records. To analyze preoperative test appropriateness, a questionnaire was designed using the CLINAPSIS platform (Appendix A: Supplementary Data 3a) and was pilot-tested before data extraction to check for functionality and to make any necessary modifications. The evaluators assessed preoperative test requests for patients for appropriateness against criteria defined by the hospital protocol or NICE guidelines.

Data were collected as follows: (i) patient data: age and sex; (ii) surgical data: with/without admission, surgery type, anesthesia type, and physical status according to the American Society of Anesthesiologists Physical Status Classification System (ASA I-IV); (iii) requested tests: requesting department and test type; (iv) test appropriateness: inappropriateness type (over- or under-requested), and appropriateness according to the hospital protocol and NICE guidelines.

To analyze interhospital protocol variability in criteria for preoperative test requests, in a second questionnaire (also designed using the CLINAPSIS platform) issued to study leaders (Appendix A: Supplementary Data 3b) data were collected as follows: existence of a specific protocol; existence of preoperative profiles or request templates; profile characteristics and included parameters; requesting department; request circuit; professional requesting the tests; specialty (if a doctor); and test validity (<6 months, 6–12 months, >12 months). Copies were obtained of existing internal preoperative test protocols if available.

To analyze interhospital variability in preoperative test request criteria, each protocol as described in terms of the specified variables was scored to determine (dis)agreement between the hospital-recommended and NICE-recommended preoperative test requests. Scores, calculated by surgical complexity and ASA grade (Appendix A: Supplementary Data 4), were assigned for the following 6 requests: complete blood count (CBC), coagulation testing, kidney function testing (KFT), pulmonary function testing (PFT), chest X-ray, and electrocardiogram (ECG). Scoring was as follows: 1 point, the recommendation is not to routinely perform the test; 1.5 points, the recommendation is to perform the test under certain conditions; and 2 points, the recommendation is to routinely request the test. Each hospital was positioned below or above the NICE total score of 58, depending on whether the internal protocol recommendations were more or less restrictive, respectively. Disagreement was then calculated as the difference between the protocol and the NICE score (the greater the difference, the greater the discrepancy). Disagreement was also calculated for each surgical complexity category and each ASA grade.

2.3. Statistical analysis

Variables were descriptively analyzed using frequencies, percentages, medians and ranges, depending on the nature of the variables. Proportions of potentially inappropriate preoperative tests were calculated according to hospital protocols and NICE guidelines, with inappropriateness analyzed by test type, hospital, surgery type and ASA grade.

To estimate the between-hospital variation in inappropriateness according to hospital protocols and according to NICE guidelines, a multilevel logistic regression model with no covariables was built for each standard. The average probability of inappropriateness and its 95 % CI were estimated applying the logit transformation to the fixed intercept. The degree of between centers variation in appropriateness is reported with the intra-level correlation coefficient (ICC), with values between 0 and 100 %, zero indicating that all observed variability in the outcome is due to individual patient variability, and 100 % indicating that all observed variability is due to between center variability [19]. Although there are no standardized thresholds for interpreting ICC values, we considered values below the 0.40 threshold to indicate that a small proportion of the total variance is attributable to differences between groups [20]. To estimate the relative impact of hospital and patient level variables (e.g. surgery type or ASA levels) on inappropriateness, univariate multilevel models with these variables as fixed effects were built.

Two multivariate multilevel logistic regression models explored the variables influencing preoperative test inappropriateness, according to hospital protocols and according to NICE guidelines. In both models, hospital-specific random intercepts were added to model between-hospital variation in inappropriateness and the models were built considering hospital-level covariables (hospital complexity, availability of a computerized preoperative request templates, and disagreement between the hospital and NICE preoperative test recommendations) and patient-level covariables (sex, age, ASA grade, surgical complexity). Multilevel models were built with the melogit command in Stata, that applies adaptive Gauss-Hermite quadrature approximations to the likelihood, which have shown on MonteCarlo simulations to have good performance for estimating variance components when the number of clusters is small [17].

Sensitivity multilevel analyses were conducted using Bayesian methods, which have been shown in MonteCarlo simulations to provide accurate estimation of variance components when fewer than 10 clusters are present [17]. Both Bayesian and frequentist approaches produced similar results, yielding comparable odds ratios and confidence/credible intervals for the observed variables (Appendix A: Supplementary Data 5). Statistical analyses outputs are available upon request.

Parsimonious multivariate models were built by sequentially eliminating non-statistically significant variables from the full model. Nested models were compared in terms of (1) intra-level correlation coefficient

(ICC) with its 95 % confidence interval for the residual degree of clustering within groups (hospitals) after adjusting by the model, and (2) Akaike Information Criterion (AIC) for the goodness of fit of the model. The model that best improved these indicators was kept. Appropriateness of the multilevel model approach was tested with a likelihood test, which compared the multilevel model with a single level logistic regression with no random intercepts; a significant result of this test indicated that the multivariate approach is more informative than the single level approach. An independent covariance structure was assumed in the multilevel models. The association between each variable and inappropriateness was expressed in terms of odds ratios (OR) with 95 % CI. No multiple comparison adjustment was made to the coefficients' *p*-values and confidence intervals. Results of the multilevel models were reported following the LEVEL recommendations [21].

All statistical analyses were conducted with a significance level of $p < 0.05$ ($\alpha = 0.05$) for a two-tailed approach. Data were analyzed using the statistical program STATA (Stata Corp. 2021. Stata Statistical Software: Release 18.0. College Station, TX: Stata Corp LLC).

3. Results

A total of 1522 patients underwent the 5 selected surgical procedures in the 9 hospitals during the recruiting period. The median number of patients was 303 (minimum 290-maximum 314) per surgical procedure and 156 (minimum 151-maximum 251) per hospital. As shown in Table 1, of the 1522 patients, 790 (51.9 %) were men, and median (IQR) age was 71 (60–77) years. Most patients were classified as ASA-II (57.9 %) or ASA-III (31.4 %).

3.1. Appropriateness of preoperative test requests

Table 2 reports inappropriateness levels for preoperative test requests. Hospitals showed high percentages of inadequacy for laboratory tests, followed by chest X-rays and ECGs. The hospitals had high percentages of over-requesting tests and low percentages of under-requesting.

Fig. 1 maps inappropriate preoperative test requests by hospital or by NICE guidelines. Inappropriateness rates varied between hospitals, according to either internal protocols or NICE guidelines. Average percentage of inappropriateness to internal protocols was 12.03 % (95 %CI: 4.40 % to 28.87 %), with considerable variability in the rates due to between centers differences (ICC = 45.1 %, 95 %CI: 22.8 % to 69.6 %). Average percentage of inappropriateness to NICE guidelines was 72.99 % (95 %CI: 60.26 % to 82.80 %), with variability in the outcome being less related to differences between centers (ICC = 18.5 %, 95 %CI: 7.8 % to 37.7 %). Inappropriateness in relation to the NICE guidelines was notable, as the rate was over 60.0 % in 8 of the 9 hospitals. The hospitals with the highest inappropriateness according to their protocols did not show the highest inappropriateness according to the NICE guidelines.

Fig. 2 depicts hospital inappropriateness of preoperative test requests according to surgery type and ASA grade. Significant differences were evident for surgery type (Fig. 2-A). According to internal protocols, percentages of inappropriateness were lowest for cataract surgery and primary knee replacement, and highest for inguinal hernia surgery and

Table 1
Patient characteristics by hospital.

Variables, n (%)	Total (n = 1522)	Hospital 1 (*n* = 151)	Hospital 2 (*n* = 155)	Hospital 3 (*n* = 164)	Hospital 4 (*n* = 175)	Hospital 5 (*n* = 156)	Hospital 6 (n = 156)	Hospital 7 (*n* = 251)	Hospital 8 (*n* = 158)	Hospital 9 (*n* = 156)
Age (median, IQR)	71 (60–77)	69 (60–77)	67 (56–72)	71 (59,5–78)	72 (63–78)	72 (62–78)	70 (60.5–77)	72 (62–78)	69.5 (56–77)	72 (62.5–79)
Male sex	790 (51.9)	85 (56.3)	78 (50.3)	80 (48.8)	85 (48.6)	90 (57.7)	91 (58.3)	132 (52.6)	85 (53.8)	64 (41.0)
Outpatient surgery	515 (33.8)	70 (46.7)	60 (39.2)	45 (27.8)	82 (46.9)	57 (36.5)	54 (34.6)	55 (21.9)	62 (39.2)	30 (19.5)
ASA grade										
I	144 (9.5)	5 (3.3)	24 (15.5)	21 (12.8)	15 (8.6)	11 (7.6)	14 (9.0)	18 (7.2)	12 (7.6)	24 (15.4)
II	881 (57.9)	102 (67.6)	87 (56.1)	73 (44.5)	111 (63.4)	102 (65.4)	81 (51.9)	153 (61.0)	89 (56.3)	83 (53.2)
III	478 (31.4)	43 (28.5)	38 (24.5)	68 (41.5)	47 (26.9)	42 (26.9)	59 (37.8)	78 (31.1)	55 (34.8)	48 (30.8)
IV	19 (1.3)	1 (0.7)	6 (3.9)	2 (1.2)	2 (1.1)	1 (0.6)	2 (1.3)	2 (0.8)	2 (1.3)	1 (0.6)
Surgery and anesthesia*										
Cataract	**314 (20.6)**	**37 (24.5)**	**31 (20.0)**	**32 (19.5)**	*35 (20.0)*	**32 (20.5)**	**31 (19.9)**	**54 (21.5)**	**31 (19.6)**	**31 (19.9)**
Topical	242 (77.3)	34 (91.9)	26 (83.9)	31 (100.0)	24 (68.6)	8 (25.0)	22 (71.0)	51 (94.4)	17 (54.8)	29 (93.5)
Locoregional	96 (30.7)	2 (5.4)	4 (12.9)	–	11 (31.4)	30 (93.8)	9 (29.0)	25 (46.3)	14 (45.2)	1 (3.2)
Sedation	118 (37.7)	7 (18.9)	21 (67.7)	–	–	25 (78.1)	31 (100.0)	3 (5.6)	–	31 (100.0)
Inguinal hernia	**303 (19.9)**	**24 (15.9)**	**33 (21.3)**	**32 (19.5)**	**35 (20.0)**	**32 (20.5)**	**31 (19.9)**	**54 (21.7)**	**31 (19.6)**	**31 (20.0)**
Locoregional	226 (75.1)	22 (91.7)	18 (58.1)	32 (100.0)	25 (71.4)	12 (37.5)	28 (90.3)	51 (94.4)	12 (38.7)	26 (83.9)
General	108 (35.9)	3 (12.5)	14 (45.2)	1 (3.1)	32 (91.4)	20 (62.5)	5 (16.1)	3 (5.6)	22 (71.0)	8 (25.8)
Sedation	78 (25.9)	11 (45.8)	13 (41.9)	1 (3.1)	–	12 (37.5)	25 (80.6)	–	–	16 (51.6)
Lap chole	**302 (19.9)**	**30 (19.9)**	**29 (18.7)**	**32 (19.5)**	**35 (20.0)**	**29 (18.6)**	**31 (19.9)**	**54 (21.7)**	**31 (19.6)**	**31 (20.0)**
General	300 (99.3)	30 (100.0)	29 (100.0)	32 (100.0)	35 (100.0)	29 (96.6)	31 (100.0)	54 (100.0)	31 (100.0)	30 (96.8)
Colon surgery	**290 (19.1)**	**30 (19.9)**	**31 (20.0)**	**34 (20.7)**	**35 (20.0)**	**29 (18.6)**	**31 (19.9)**	**35 (14.1)**	**34 (21.5)**	**31 (20.0)**
Locoregional	149 (51.6)	23 (76.7)	21 (67.7)	27 (79.4)	34 (97.1)	1 (3.4)	11 (35.5)	3 (8.8)	29 (85.3)	–
General	289 (99.7)	30 (100.0)	31 (100.0)	34 (100.0)	35 (100.0)	29 (100.0)	31 (100.0)	34 (97.1)	34 (100.0)	31 (100.00)
Primary knee rep	**313 (20.6)**	**30 (19.9)**	**31 (20.0)**	**34 (20.7)**	**35 (20.0)**	**34 (21.8)**	**32 (20.5)**	**54 (21.5)**	**31 (19.6)**	**32 (20.5)**
Locoregional	305 (97.4)	30 (100.0)	30 (96.8)	33 (97.1)	35 (100.0)	32 (94.1)	32 (100.0)	54 (100.0)	31 (100.0)	28 (87.5)
General	12 (3.8)	1 (3.3)	1 (3.23)	–	2 (5.7)	2 (5.9)	2 (6.3)	–	–	4 (12.5)
Sedation	111 (35.5)	10 (33.3)	–	1 (2.9)	32 (91.4)	15 (44.1)	28 (87.5)	–	1 (3.2)	24 (75.0)

ASA: American Society of Anesthesiologists physical status grade; IQR: interquartile range (25th–75th percentile). Lap Chole: Laparoscopic cholecystectomy; Primary knee rep: Primary knee replacement.
Except for age (median, IQR), all cells present the number of patients and the percentage of the total for each hospital. For each surgical procedure, the percentages of the total number of patients with the procedure were calculated.
* Percentages may exceed 100 % as patients could have more than one anesthesia modality.

Table 2
Percentages of inappropriate preoperative test requests from the nine participating hospitals according to internal hospital protocols and NICE guidelines*.

	Hospital protocols			NICE guidelines		
	Excess	Deficit	Total	Excess	Deficit	Total
Laboratory tests	11.4 % (0.0 %–54.4 %)	0.0 % (0.0 %–5.7 %)	13.2 % (13.2 %–54.4 %)	60.0 % (19.9 %–91.1 %)	1.9 % (0.0 %–7.1 %)	60.3 % (20.5 %–91.1 %)
Chest X-rays	1.3 % (0.0 %–37.8 %)	0.6 % (0.0 %–13.9 %)	5.1 % (0.0 %–39.1 %)	4.4 % (0.0 %–71.8 %)	0.0 % (0.0 %–1.3 %)	4.4 % (0.0 %–72.4 %)
ECGs	1.9 % (0.0 %–18.6 %)	0.6 % (0.0 %–9.3 %)	2.6 % (0.0 %–23.1 %)	16.5 % (2.9 %–32.3 %)	1.8 % (0.4 %–9.3 %)	18.3 % (5.7 %–32.9 %)
PFTs	0.0 % (0.0 %–5.8 %)	0.0 % (0.0 %–0.0 %)	0.0 % (0.0 %–5.8 %)	0.0 % (0.0 %–5.1 %)	0.0 % (0.0 %–7.6 %)	0.7 % (0.0 %–7.7 %)

Excess: over-requested preoperative tests (ordered when not indicated). Deficit: under-requested preoperative tests (not ordered despite being indicated).
Laboratory tests: full complete blood count (coagulation, glucose, creatinine, electrolytes, liver enzymes, anemia).
NICE: National Institute for Health and Care Excellence; ECG: electrocardiogram; PFT: pulmonary function test.
* The percentage of inappropriate tests was calculated according to the total number of patients in each hospital. In each cell, the median of the inappropriateness percentages and the (minimum-maximum) percentages among the 9 hospitals in the study are presented.

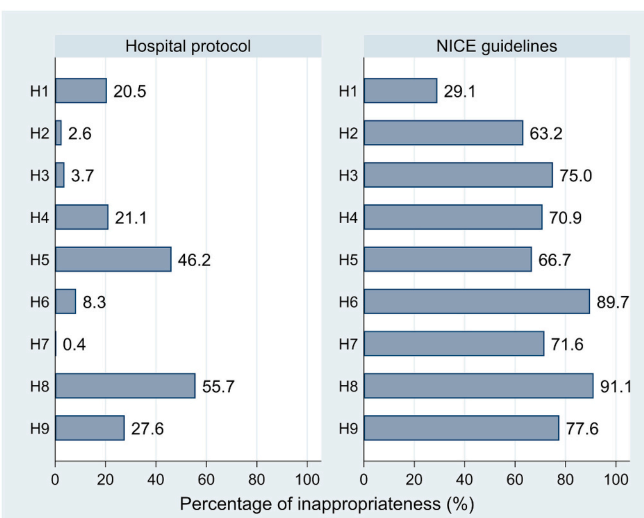

Fig. 1. Inappropriateness (%) according to hospital protocols and the NICE guidelines.*
* The inappropriateness percentages were calculated with all surgeries that followed the hospital protocol (left) or NICE guidelines (right) as the numerator, and in both cases all of the hospital's surgeries as the denominator.
Average percentage of inappropriateness according to hospital protocols was 12.03 % (4.40 % - 28.87 %).
Average percentage of inappropriateness according to NICE guidelines was 72.99 % (60.26 % - 82.80 %).
NICE, National Institute for Health and Care Excellence.

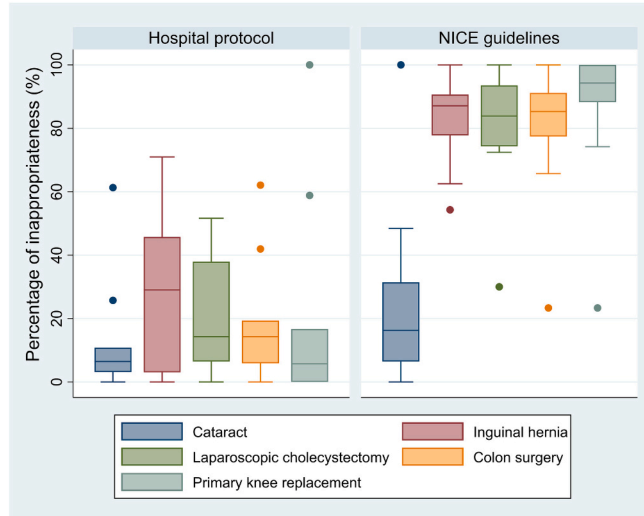

Fig. 2A. Box plot of hospital inappropriateness according to internal protocols and the NICE guidelines by surgery type and ASA grade. **2A. Inappropriateness by surgery type***.
* p < 0.001 for differences in inappropriateness between surgery types according to hospital protocols and the NICE guidelines with multilevel models.
ASA, American Society of Anesthesiologists physical status grade; NICE, National Institute for Health and Care Excellence.

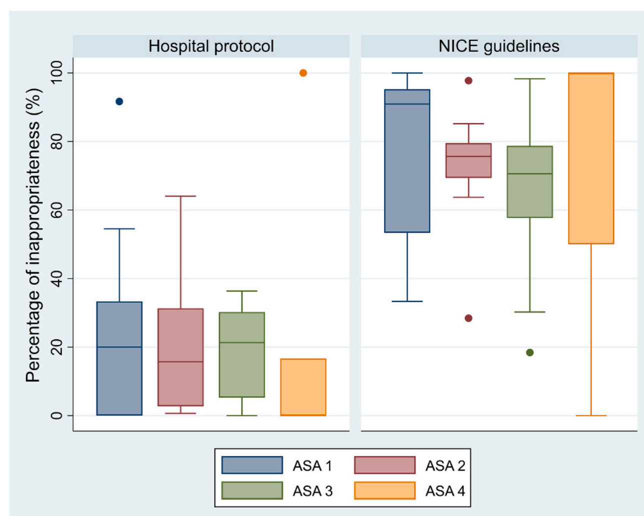

Fig. 2B. Box plot of hospital inappropriateness according to internal protocols and the NICE guidelines by surgery type and ASA grade. **2B. Inappropriateness by ASA grade***.
* p = 0.083 and p = 0.064 for differences in inappropriateness between ASA grades according to hospital protocols and the NICE guidelines respectively with multilevel models.
ASA, American Society of Anesthesiologists physical status grade; NICE, National Institute for Health and Care Excellence.

laparoscopic cholecystectomy ($p < 0.001$; univariate multilevel model). According to the NICE guidelines, the lowest inappropriateness rates were for cataract surgery, while inappropriateness rates were high for all the remaining surgeries ($p < 0.001$; univariate multilevel model). Regarding ASA grades (Fig. 2-B-B), differences in inappropriateness according to internal protocols or according to NICE guidelines did not reach statistical significance ($p = 0.083$ and $p = 0.064$ respectively; univariate multilevel model).

The multilevel logistic regression models explored variables that were associated to the inappropriateness of preoperative test requests according to hospital protocols and the NICE guidelines (Table 3). The risk of inappropriateness according to hospital protocols increased significantly for the following patient-level variates: younger age and undergoing intermediate- and high-complexity surgery. No hospital level covariables were kept in the parsimonious model. The multilevel model showed high residual variability between centers after adjusting for patient-level covariables (ICC = 46.4 %, 95 %CI: 23.7 % to 70.6 %),

Table 3
Center and patient factors associated to preoperative test inappropriateness according to hospital protocols and the NICE guidelines.

Independent variable	Value of category	Hospital protocols OR (95 % CI)	NICE guidelines OR (95 % CI)
Hospital level variables			
Hospital complexity	Low		1
	Intermediate		1.51 (0.43 to 5.31)
	High		3.64 (1.03 to 12.85))
Computerized preoperative request templates	No		1
	Yes		0.11 (0.04 to 0.30)
Patient level variables			
Age, years		0.98 (0.97 to 0.99)	
ASA grade	III/IV		1
	I/II		1.91 (1.40 to 2.60)
Surgical complexity	Low	1	1
	Intermediate	2.23 (1.42 to 3.51)	18.95 (12.92 to 27.79)
	High	1.70 (1.10 to 2.62)	27.93 (18.60 to 41.95)
Model statistics			
Null model* n, hospital ICC (95 %CI)		$n = 1521$, 45.1 % (22.8 % to 69.6 %)	n = 1521, 18.5 % (7.8 % to 37.7 %
Final model n, hospital ICC (95 %CI)		n = 1521, 46.4 % (23.7 % to 70.6 %)	n = 1521, 11.0 % (4.0 % to 26.9 %)
Likelihood ratio test **		p value <0.001	p value <0.001
AIC		1161.8	1275.6

Variables considered in the multilevel model: 1) hospital-level variables: hospital complexity, availability of a computerized preoperative request templates, and disagreement between the hospital and NICE preoperative test recommendations, and 2) patient-level variables: sex, age, ASA grade and surgical complexity.
CI: confidence interval; ASA: American Society of Anesthesiologists physical status grade; ICC: intra-level correlation coefficient; AIC: Akaike Information Criterion.
* Null multilevel model with random intercepts per hospital, and no covariables.
** Test comparing the multilevel model with random intercepts against a single level logistic regression model with no random effects. P value <0.05 indicates that the multilevel model is more informative than the single level model.

suggesting a moderate degree of heterogeneity across centers despite adjusting for relevant covariables. The risk of inappropriateness according to the NICE guidelines was significantly higher for the following hospital-level variables: high complexity of the center and non-availability of computerized preoperative request templates; patient-level variables that showed a statistically significant risk of inappropriateness were ASA I/II grades and intermediate- and high-complexity surgery. The latter model was able to further reduce the residual between-hospitals variability in inappropriateness after adjusting for relevant patient and hospital covariables (ICC = 11.0 %, 95 %CI: 4.0 % to 26.9 %), suggesting little heterogeneity between hospitals in the degree of inappropriateness to NICE protocols. The Bayesian analysis yielded consistent results to the multilevel logistic regression models (Appendix A: Supplementary Data 5).

3.2. Interhospital protocol variability

All 9 hospitals had internal protocols prescribing criteria for preoperative test requests (Appendix A: Supplementary Data 6). Protocol heterogeneity between hospitals was significant, since criteria were based on input from different surgical specialties and bibliographical references were lacking. Protocol formats were also highly variable, and editing was generally of poor quality.

Table 4 summarizes disagreement (score differences) between hospital protocols and the NICE guidelines according to surgical complexity and ASA grade. Most score differences were greater than zero, indicating that hospital protocols recommended more preoperative tests than the NICE guidelines. Disagreement with NICE recommendations was evident from the magnitude of the median (IQR) differences in the total surgical complexity and ASA grade scores: 11.0 (10.5, 15.0) and 10.5 (5.0, 15.0), respectively. There were important differences between hospitals in the discordance with NICE guidelines for surgical complexity and for ASA grades. For surgical complexity, the greatest discordance (highest score differences) was for intermediate-complexity surgeries (inguinal hernia, laparoscopic cholecystectomy), followed by high-complexity surgeries (colon surgery and primary knee replacement). As for ASA grade, the greatest discordance was for ASA—I, followed by ASA-II. As would be expected, inappropriateness according to the NICE guidelines tended to be greater in hospitals whose internal protocols were in greater discrepancy with the NICE guidelines (Appendix A: Supplementary Data 7).

4. Discussion

In analyzing the appropriateness of requests for preoperative tests for 5 elective surgical interventions of different complexity, we provide a representative view of current care practices in nine Spanish public hospitals. We found poor compliance with both internal protocol and NICE guidelines for preoperative test requests. We also found that interhospital appropriateness of preoperative test requests varied significantly.

4.1. Appropriateness of preoperative test requests

Most published studies on preoperative testing have focused on percentages of previously unknown abnormal test results, changes in perioperative management [22], unnecessary testing rates [23], and perioperative adverse event rates [2,24–29]. However, few studies have analyzed how (in)appropriate preoperative test requests may be according to the recommendations of evidence-based guidelines. In our study, we observed that only a small percentage of preoperative test requests met the hospitals' own protocol criteria, and that an even smaller percentage complied with the NICE guidelines.

Hospitals with the lowest adherence to their protocols did not show the lowest adherence to the NICE guidelines. This could be explained because of the high percentages of inappropriateness according to the NICE guidelines in most hospitals. Therefore, the high inappropriateness level according to the NICE guidelines pointed to no relationship between preoperative test request inappropriateness according to hospital protocols and according to NICE guidelines.

Our inappropriateness rate in relation to the NICE guidelines (72.99 %) is higher than those reported elsewhere. Matulis et al. [23] observed unwarranted testing rates of 23 %–36 % for their patients; Chen et al. [30] found that 53 % of Medicare beneficiaries undergoing cataract surgery underwent at least one preoperative test, despite strong evidence as to the lack of benefit; Kirkham et al. [31,32] reported a rate of 30 %, 31 %, and 11 % for preoperative laboratory tests requested prior to low-risk procedures, ECGs, and chest X-rays, respectively, despite guidelines recommendations to limit testing.

Inappropriateness was mostly due to an excessive number of test requests. Multiple reasons for over-requested preoperative tests have been described in the literature [2,3], e.g., excessive professional zeal in making a test request, even when not clearly indicated, and clinical judgement leading to individualized decision-making that diverges from the protocol. Several other reasons include legal concerns, a tendency to

Table 4
Disagreement regarding preoperative test indications between hospital protocols and the NICE guidelines according to surgical complexity and ASA grade. *

A. Disagreement by surgical complexity

	LOW	INTERMEDIATE	HIGH	TOTAL
NICE	0	0	0	0
Hospital 1	1.5	5	4	10.5
Hospital 2	-0.5	7	4	10.5
Hospital 3	-0.5	11	6.5	17
Hospital 4	1	5	4	10
Hospital 5	-0.5	2	3.5	5
Hospital 6	-0.5	6.5	5	11
Hospital 7	5.5	5.5	4	15
Hospital 8	5.5	5.5	4	15
Hospital 9	10.5	8	3.5	22
Median (IQR)	1.0 (-0.5, 5.5)	5.5 (5.0, 7.0)	4 (4.0, 4.0)	11.0 (10.5, 15.0)

B. Disagreement by ASA grade

	ASA I	ASA II	ASA III-IV	TOTAL
NICE	0	0	0	0
Hospital 1	4	2	-1	5
Hospital 2	5.5	3.5	1.5	10.5
Hospital 3	8	6	3	17
Hospital 4	3.5	1.5	4.5	9.5
Hospital 5	4	2	-1	5
Hospital 6	6	4	1	11
Hospital 7	1.5	-0.5	0	1
Hospital 8	5.5	5.5	4	15
Hospital 9	9	8	5	22
Median (IQR)	5.5 (4.0, 6.0)	3.5 (2.0, 5.5)	1.5 (0.0, 4.0)	10.5 (5.0, 15.0)

Legend
Disagreement between hospital protocol and the NICE guidelines by color:

Lowest disagreement -1 to 1.5	2 to 3	4 to 5.5	6 to 7	Highest disagreement 8 to 11

*Disagreement was calculated as the score difference between each hospital protocol and the NICE guidelines (see Methods).
ASA: American Society of Anesthesiologists physical status grade; NICE: National Institute for Health and Care Excellence; IQR: interquartile range (25th, 75th percentile).

practice defensive medicine, institutional rules, fears that another doctor may consider the preoperative test necessary and so delay or cancel the intervention, lack of awareness of published guidelines, provider practice patterns, and the excessive value attributed to tests under a general misconception that medical tests cannot be harmful [3,5,30,33,34].

In our study, inappropriateness was much higher according to the NICE guidelines than according to internal hospital protocols. This may be illustrative of how difficult it can be to translate guidelines into clinical practice, and also suggests that hospitals may tend to apply more permissive criteria when drawing up their protocol with doctors from different specialties. International guidelines issued by organizations, societies, and task forces tend to be more evidence-based and therefore more restrictive. However, the fact that important differences also exist between even high-quality clinical practice guidelines points to the complexity of issuing general preoperative recommendations for perioperative patient management [35,36].

The most inappropriate preoperative test requests in our study were for laboratory tests, followed by chest X-rays and ECGs, and inappropriate preoperative test requests differed by hospital and surgery type. Hospital variations in preoperative testing prior to low-risk surgeries was documented in detail for hospitals in Ontario (Canada) by Kirkham et al. [31,32], who reported rates of exposure to preoperative tests of 0.0 %–98.2 % (laboratory tests), 3.4 %–88.8 % (ECGs), and 1.6 %–51.0 % (chest x-rays). Our multilevel models showed a moderate between-center variability in unnecessary preoperative testing according to internal hospital protocols after adjusting for covariables. These results call for reflection. Interhospital variability may reflect different internal protocol criteria, different procedures for requesting preoperative tests (e.g., the existence of preoperative request profiles or templates or organizational request circuits), or different doctor actions regarding test requests. As for variability by surgery type, according to the hospital protocols low-complexity surgeries (cataract surgery) were the least unnecessary requests followed by high-complexity surgeries, and intermediate-complexity surgeries were the most unnecessary requests. According to the NICE guidelines low-complexity surgeries featured also the least unnecessary preoperative test request, and unnecessary requests were notably high for the remaining surgeries. A probable reason for appropriate preoperative testing for cataract surgery is that some study hospitals had specific recommendations or even explicit protocols regarding this surgery. On the other hand, the NICE guidelines do not specifically recommend preoperative anemia testing, despite this test being routinely performed for surgeries with a moderate-to-high bleeding risk. Anemia testing has been recommended as part of patient blood management programs in recent years. Note that, in Spain, consensus and acceptance of this test is high for enhanced-recovery-after-surgery interventions [37–39]. Consequently, in relation to our study, anemia testing prior to high-complexity surgeries probably contributed to the corresponding high inappropriateness rates in relation to the NICE guidelines.

Finally, we explored independent factors leading to inappropriate preoperative test requests in a multilevel analysis. At hospital level, an interesting finding is the increased risk of inappropriate test requests according to NICE guidelines by high-complexity hospitals (tertiary level hospitals) relative to low-complexity hospitals (small regional hospitals). One possible explanation is that the involvement of more professionals from more surgical specialties in the dissemination and implementation of preoperative test protocols may reduce adherence. Further studies will be needed to replicate this finding and to determine the reason for this relative difference in hospitals according to their complexity. Other hospital-level variable was the non-availability of computerized preoperative request templates, which increased the risk of inappropriateness according to the NICE guidelines. At the patient-level, the analysis confirmed, as reported above, that intermediate- and high-complexity surgeries were associated with an increased risk of unnecessary requests. This finding, if confirmed by other studies, may be relevant, as existing studies have tended to focus more on inappropriateness for surgeries of low and moderate complexity and few studies have found inappropriateness for high-complexity surgeries [40,41]. Other patient-level variables were younger ages, which increased the risk of inappropriateness according to hospital protocols, and ASA I/II grades relative to ASA III/IV, which increased the risk of inappropriateness according to the NICE guidelines. Younger patients as well as ASA I/II patients – more fundamentally healthy or having only mild systemic diseases – are clearly placed at risk when, regardless of surgical complexity, preoperative tests are over-requested.

4.2. Interhospital protocol variability

All hospitals had preoperative testing protocols, but formatting and editing were generally poor. Recommendations varied greatly, possibly contributing to their low observed agreement with the NICE guidelines. Furthermore, the hospital protocols tended to be less restrictive than the NICE guidelines, especially for intermediate-complexity surgeries and ASA-I grades. The distribution of disagreement with the NICE guidelines by surgical complexity and by ASA grade was similar to the distribution of inappropriateness according to the NICE guidelines, with the exception that inappropriateness in terms of the NICE guidelines was notable for intermediate- and high-complexity surgeries. Consequently, and as expected, inappropriateness tended to be greater in hospitals whose protocols disagreed with the NICE guidelines.

From the included hospital protocols, we could identify two main reasons for inappropriateness. First, doctors tend to over-request tests for professional and contextual reasons (as described above). Second, hospitals are governed by their institutional protocols in terms of agreed indications, protocol dissemination and implementation, and organizational circuits that determine how tests are requested. We suggest that hospitals need to invest greater effort in properly protocolizing preoperative tests using an institutional format and in updating protocols regularly with scientific evidence on clinical decision-making effectiveness and cost-effectiveness [1]. Our results would indicate that special attention should be paid to intermediate-complexity surgeries in low-comorbidity patients and to high-complexity surgeries, with the aim of avoiding unnecessary preoperative tests, ensuring more efficient pre-anesthetic assessment, and reducing costs for the institution [42,43].

Our findings confirm the need for selective and rational preoperative test requests based on clinical assessment during the pre-anesthetic visit [22,44]. Interventions shown to reduce unnecessary preoperative test requests include high-quality local practice guidelines and clinician education, complemented by audits and feedback [1,3,7]. Training for doctors needs to be more systematic, and should be related not only to anticipated procedural risks, but should also emphasize the importance of careful test selection based on patient needs, guided by a targeted history and physical examination, and informed by a medical record review (to determine specific comorbidities and consult recent results) [5]. Hospitals, moreover, need to consider how best to communicate, disseminate, and ensure correct implementation of their protocols [45]. Digital tools integrated into electronic medical records, for instance, could provide guidance on appropriate preoperative test requests (e.g., computerized preoperative request templates). They may lead to a reduction in unnecessary test requests as other quality improvement initiatives in preoperative testing have shown [23,46].

4.3. Study limitations

Our study has several limitations. The retrospective cross-sectional design made it difficult to review hospital medical records to assess the appropriateness of requested preoperative test requests. Furthermore, the profiles of the study reviewers, which varied depending on the hospital (anesthetists and other specialists), may have affected internal validity. Additionally, there was no external validation of the appropriateness of the preoperative test by independent investigators at the hospital where the tests were performed. However, the observed inappropriateness has been high, so we believe that the effect may have been small. Otherwise, the inappropriateness could be even greater.

Our overall findings should also be interpreted with caution as the results from June 2022 may be outdated. Yet, the magnitude of the low value preoperative testing is not easy to reduce in the short term [3,16]. On the other hand, it should be noted that the time period studied (≥5 working days in a month) may limit the reliability of the study if unnecessary tests are not performed consistently over time. However, as previously stated, appropriateness seems less determined by random or temporal factors and more by institutional and organizational aspects. For this reason, a typical or standard week was considered, during which these determinants would correspond to the annual average.

The results with the NICE guidelines should also be interpreted with caution. First, they were published in 2016, although it is still considered one of the most recognized international guidelines. Second, it specifically indicates that ultimate decision-making regarding preoperative tests depends on individual clinical circumstances. NICE leaves the test request decision for specific surgical complexity categories and ASA grades to professional discretion, exercised according to the specific patient characteristics, and even recommends seeking advice from a senior anesthetist after assessment. Given these subjective specifications, it may be difficult to establish when a request for preoperative testing is appropriate or inappropriate, most especially when appropriateness is analyzed in a categorical yes/no manner, as done in our study.

A further limitation is that the study was not originally designed to be analyzed under a multilevel approach, and the number of participating centers was somewhat below the recommendations of the methodological literature, albeit the number of participants per center was generous and higher that usual recommendations [17,20]. The consequence of this low number of centers is the possibility of biased estimates of the variability between hospitals. The statistical analyses were designed to address this limitation, employing methods that have been shown to be appropriate for multilevel models with a small number of centers. Furthermore, our interpretations have been tempered by the inherent uncertainty of these analyses and are exploratory in nature. Accordingly, further studies involving larger samples of hospitals are warranted.

5. Conclusions

According to the internal protocol criteria of the hospitals in our study, and most especially according to the NICE guidelines, the level of inappropriateness in requesting preoperative tests is unacceptably high. Our findings highlight the interplay between patient characteristics, surgical complexity, and institutional factors in influencing the appropriateness of preoperative testing. The fact that inappropriateness varied by hospital can be explained by great interhospital variability in criteria for preoperative test requests, but generally leading to overuse of preoperative tests. Hospitals need to ensure that their protocols are up-to-date, evidence-based, and of high quality, and should implement actions to reduce unwarranted preoperative testing in the interest of reducing their negative clinical and economic impact.

CRediT authorship contribution statement

Antonio Sánchez-Hidalgo: Conceptualization, Methodology, Resources, Writing – original draft, Writing – review & editing, Supervision. **Iratxe Urreta Barallobre:** Conceptualization, Methodology, Formal analysis, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision. **Ignasi Bolibar Ribas:** Conceptualization, Methodology, Resources, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration. **Eva Bassas Parga:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Miren Arrieta Bernaras:** Conceptualization, Methodology, Resources, Writing – original draft, Writing – review & editing. **Gaizka Gutiérrez Sánchez:** Writing – original draft, Writing – review & editing. David Sánchez Cirera: Writing – original draft, Writing – review & editing. **Francisco José González Moraga:** Resources, Writing – original draft, Writing – review & editing. **Inigo Gorostiza:** Writing – original draft, Writing – review & editing. **Raúl de Frutos Parra:** Resources, Writing – original draft, Writing – review & editing. **Susana Álvarez Gómez:** Resources, Writing – original draft, Writing – review & editing. **Pablo Manuel Keenoy:** Resources, Writing – original draft, Writing – review & editing. **Marta Roqué Figuls:** Formal analysis, Data curation, Writing – review & editing, Visualization. **Carolina Requeijo:** Conceptualization, Methodology, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this manuscript and its revisions, the authors used ChatGPT 3.0 to improve the translation, readability, and language of the manuscript and supplementary data. After using this tool, the authors and the linguistic editor revised the content as needed and assumed full responsibility for the content of the publication.

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Declaration of competing interest

The authors report no conflicts of interest in this work.

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Appendix A. Supplementary data

Statistical output for both frequentist and Bayesian analyses are available upon request. Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclinane.2025.112033.

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