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Editorial

Mark Skues, Editor-in-Chief

As the year comes to an imminent end, so comes the 3rd edition of *Ambulatory Surgery* for 2025. This quarter's edition contains four papers that should be of interest to all.

First off, is a manuscript examining the variation in unplanned admission rates after ambulatory surgery from North Carolina, USA. The authors evaluated patient data for ten years to determine factors associated with unplanned admissions. Overall, the rate of admission was 4.1%, with rates higher for black and others compared with white patients. This is a well recognised phenomenon, for which the authors can offer no explanation from the extensive data that they collected.

Similar to this paper, is one from Spain where the authors evaluated unplanned overnight stays or subsequent hospital re-admissions. In their series of 3,397 patients, nearly one in four experienced failure of ambulatory surgery, associated with procedure duration, placement of a central venous access device, and the use of general or spinal anaesthesia. The existence of co-morbidities, together with inevitable complications would seem to be a potential explanation.

The third paper evaluates the sustainability of infusion syringes versus drop counters for ambulatory surgery. In a complex paper evaluating many criteria over a period of weeks, the authors came to the conclusion that drop counter equipment resulted in environmental and economic benefits representing a more sustainable, ergonomic and cost efficient alternative.

Finally, an affirmation from Minneapolis USA of the importance of patient positioning in successful airway management. The author re-emphasises the relevance of positioning in first pass success of airway instrumentation in the ambulatory setting. Head elevation and aligned positioning remains fundamental to successful airway management, and perhaps the first rule in the mantra of difficult airway management.

In conclusion; I wish you all a peaceful and restful seasonal period, and a fruitful new year. Perhaps a useful resolution may be to consider formalising your opinions, finishing that review, or completing that study so that you can submit your labours to the *Journal* for review. I will be more than happy to publish your endeavours, so, keep them coming.

Dr Mark Skues
Editor-in-Chief

Variation in Unplanned Admission Rates Post-Ambulatory Surgery

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Abstract

Aim: Study race & unplanned admission (UA) post-ambulatory surgery.
Methods: Retrospective analysis of ambulatory surgeries from July 2014-June 2023 served by single academic institution. Cases surveyed for age, race, gender, length of stay (LOS), ASA status, BMI, start time, muscle relaxant use, COVID-19 vaccination, surgical specialty, academic year.
Results: UA rates were higher for Black & Other patients compared to White patients, even after multiple covariate adjustment. Overall UA rates have risen since 2014, especially for Black patients, with consistently higher UA rates than White patients throughout study.
Conclusion: Minorities, especially Black patients, face higher UA rates post-ambulatory surgery.

Keywords: Ambulatory Surgery, Racial Disparity, Racial Health Disparity.

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Introduction

Changes in surgical care over the past few decades have shifted many surgeries from the inpatient to ambulatory setting.(1) While previously restricted to simple surgeries and healthy patients with low risks of morbidity and mortality, ambulatory surgery is now available to patients with more complex conditions and increasingly complicated procedures.(1) Given that ambulatory surgery is economical and efficient, and for many, convenient; it has increasingly become the preferred setting for many procedures.(2)

However, unplanned admissions after ambulatory surgery temper some of these advantages, such as those previously mentioned, including reduced risk of infection, less stressful overall experience compared to traditional hospital inpatient stay, and generally faster recovery in the comfort of their own home.(3) Recent literature(1–8) has suggested racial disparities in access to outpatient surgery and post-operative readmissions. However, few have explored the association of race with unplanned admission post-ambulatory surgery, and none have previously included all outpatient surgeries at an American institution for greater than 8 years.

Given these previous findings, we hypothesize that unplanned admissions disproportionately affect groups that have been historically marginalized, thus not receiving the full benefits of ambulatory surgery. We herein assess how race may influence the rate of unanticipated admission post-ambulatory surgery.

Methods

We performed a cross-sectional, retrospective analysis of all ambulatory surgeries served by the Department of Anesthesiology at the University of North Carolina (UNC) at Chapel Hill (single-center, tertiary care, academic institution in Southeast United States) from July 1, 2014 to June 30, 2023. This study was approved by UNC IRB committee (#16-0950) and requirement for written informed consent was waived. Ambulatory cases were identified based on surgery class labeled as "Outpatient" or "Hospital Outpatient."

Cases were surveyed for age, gender, race, length of stay (LOS), American Society of Anesthesiologists (ASA) Physical Status, body mass index (BMI), anesthesia start time (morning vs. afternoon), muscle relaxant use, COVID-19 (SARS-CoV-2) vaccination, surgical specialty, and academic year (labeled with beginning calendar year only) from the electronic medical record. These covariates were selected based on their association with operative risk and were used to help isolate the correlation between race and unplanned admission in our logistic regression model. It may be surprising that a patient classified at ASA 4 would have planned outpatient surgery. However, relatively simple procedures may be performed in the outpatient setting, such as AV fistula procedures in renal failure patients or minor skin surgeries in cardiac patients.

Five racial categories were included: American Indian/Alaskan Native (AIAN), Asian, Black, Other, Unknown, and White. These categories were chosen based on having a case load greater than 2,000 during our study period. Other is defined as having a different race indicated, "Other" race reported, or more than 1 race reported. Unknown is defined as "prefer not to answer" or blank. Unplanned admissions occurred on the same day as surgery and were defined as cases with a LOS of 1 day or more. LOS of 0 days was considered same-day discharge.

Since Epic was implemented at our institution in May 2014, we elected to use academic year (beginning of July to end of June) as we wanted to compare full 12-month periods without losing data from 2014. All personal record information was removed from the data prior to analysis. Database was obtained using North Carolina Translational and Clinical Sciences Institute (grant-funded, UNC School of Medicine-associated institute that aids researchers in Clinical Informatics and Electronic Health Record Data). Most of our data is objective, however, we acknowledge that the race reported within Epic is subject to provider input and may not always be self-reported. While we strongly advocate for self-reporting, this also reflects observed race. This manuscript adheres to the applicable STROBE guidelines.

Statistical Analysis

Rates of unplanned admissions within patient groups (defined based on race, age, and academic year of surgery) were compared using a chi-squared test. For covariates with more than two categories, post hoc analysis was used to compare prespecified pairs of groups, and multiple tests were corrected using Bonferroni correction (5 tests). A multivariate analysis of the entire data set was also performed, adjusting for multiple covariates associated with post-surgical outcomes (detailed in the results). Missing percentages are very low (<1%) for all variables used in this study except for BMI (7.7% missing). As a result, only complete cases were used in analyses. The threshold for statistical significance for all tests was set at p 0.05.

All statistical analyses were performed using R (version 4.3.2). The reference group for all comparisons were patients whose reported race was White.

In order to view data longitudinally and remove the possible biases that arise from assessing data collected over a long period of time (i.e., since clinical practice and the race distribution may have changed between 2014-2023), rates of unplanned admission following ambulatory surgery were plotted for each academic year of the study period. An analysis of variance (ANOVA) test was employed to determine if rates were different over the years. Logistic regression was used to evaluate overall admission rate trends and analyze the interaction between race, unplanned admission, and academic year.

Results

Overall Study Group:

The overall rate of unplanned admissions was 4.1% (13,791/335,815). The study population was 65.2% White, 20.6% Black, 10.0% Other, 1.8% Unknown, 1.6% Asian, and 0.8% American Indian/Alaskan Native (AIAN). The overall association between race and rates of unplanned admissions was significant (Table 1). Post hoc analysis showed that the rates of unplanned admission were higher for patients whose reported race was AIAN (5.3%, $p < 0.001$), Black (5.0%, $p < 0.001$), and Other (4.2%, $p = 0.003$), and lower for Asian (3.0%, $p = 0.009$) and Unknown (2.9%, $p = 0.001$), compared to White (3.9%, reference) patients.

Table 1 Race and Unplanned Admission. Overall association between race and rates of unplanned admission was significant. Post-hoc analysis showed that the rates of unplanned admission were higher for patients whose reports race was American Indian/Alaskan Native (AIAN), Black, Other, and lower for Asian and Unknown, compared to White patients (reference population).

Race	Unplanned Admission Rate	Unplanned Admissions/ Total	Corrected p-value from post-hoc
AIAN	5.3%	149/2,821	<0.001
Asian	3.0%	159/5,251	0.011
Black	5.0 %	3,429/69,192	<0.001
Other	4.2%	1,733/41,619	0.003
Unknown	2.9%	173/5,933	0.001
White	3.9%	8,456/219,071	Reference

ASA Status Stratification:

When stratified by ASA status, our findings remained similar to those for the overall group. A statistically significant higher rate of unplanned admissions was found for Black patients compared to White patients in all ASA statuses except 4 (p range < 0.001) (Figure 1). Patients of other race also had a higher rate of unexpected admission than White patients, reaching statistical significance in ASA 2-3 (p range 0.002). AIAN patients showed a statistically significant higher rate of unplanned admission in ASA 2 only ($p < 0.001$). ASA 4 showed no statistically significant differences.

Age Stratification:

When stratified by age group (i.e., 0-10, 11-20), analyses show Black patients have a statistically significant higher rate of unplanned admission compared to White patients in every decade of life from 11 to 70 (p range 0.001) (Figure 2). Patients who reported other race have statistically significant higher rates of unplanned admission in age groups 11-20 and 41-50 (p range < 0.001). Asian patients were statistically less likely to be admitted in the 61-70 age group when compared to White patients ($p = 0.002$).

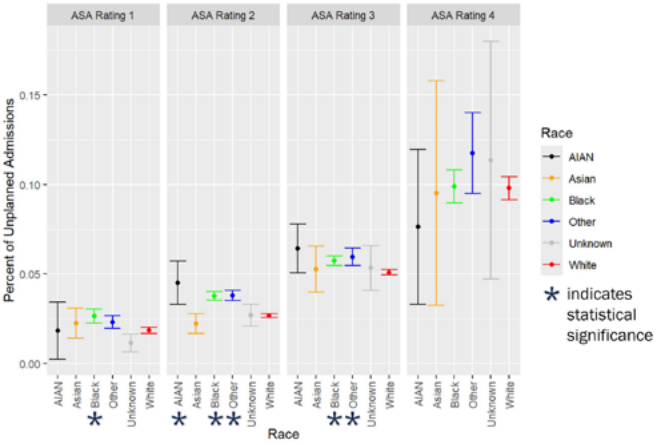

Figure 1. Association of Race with Unplanned Admission Post-Ambulatory Surgery Stratified by ASA Status. Stratification by ASA status shows that Black patients have a significantly higher rate of unplanned admissions compared to White patients in all ASA groups except 4. Patients of Other race also have higher rates in ASA 2-3, while AIAN patients show a higher rate only in ASA 2. No significant differences were found in ASA 4. * indicate statistical significance. AIAN = American Indian/Alaskan Native, ASA = American Society of Anesthesiologists (Physical Status).

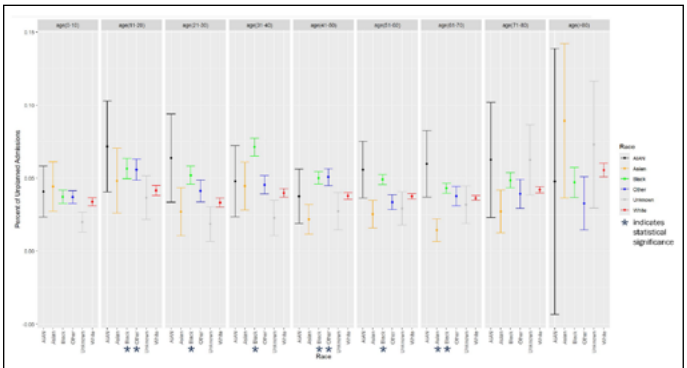

Figure 2. Association of Race with Unplanned Admission Post-Ambulatory Surgery Stratified by Age. Stratification by age group reveals that Black patients have a significantly higher rate of unplanned admissions compared to White patients across all age groups from 11 to 70. Patients of Other race have higher rates in age groups 11-20 and 41-50, while Asian patients are less likely to be admitted in the 61-70 age group compared to White patients. * indicate statistical significance. AIAN = American Indian/Alaskan Native, ASA = American Society of Anesthesiologists (Physical Status).

Multivariate Analysis:

A multivariate logistic regression model was run on the overall group examining the association of race with unplanned admission, adjusted for the following covariates: age, ASA status, gender, BMI group (Underweight <18.5, Healthy 18.5-24.9, Overweight 25-29.9, Obese 30-39.9, Severe Obesity 40), anesthesia start time (morning vs. afternoon), muscle relaxant use (yes vs. no), COVID-19 vaccination status, surgical specialty, and academic year (Table 2). Results suggest that compared with patients whose reported race was White, patients reported as Black (OR 1.1639, CI (1.114, 1.216), $p < 0.0001$) and Other (OR 1.1364, CI (1.066, 1.211), $p < 0.0001$) have a statistically significant higher rate of unplanned admission. Given the relatively high missing percentage for BMI (7.7%), multivariate analysis without BMI was conducted and produced very similar results to the model with BMI included, i.e., no change in significant results (Supplemental Table 1, shows unchanged significance compared to Table 2).

Table 2 Multivariate Logistic Regression of Race and Unplanned Admission. Adjusted with the following covariates: age, ASA status, gender, BMI group (Underweight <18.5, Healthy 18.5-24.9, Overweight 25-29.9, Obese 30-39.9, Severe Obesity ≥40), anesthesia start time (morning vs. afternoon), muscle relaxant use (yes vs. no), COVID-19 vaccination status, surgical specialty, and academic year. Results suggest that compared with patients whose reported race was White, patients reported as Black and Other have a statistically significant higher rate of unplanned admission. AIAN = American Indian/Alaskan Native, CI = Confidence Interval.

Race	Odds Ratio (95% CI)	P-value
AIAN	1.096 (0.913,1.305)	0.3162
Asian	0.984 (0.823,1.167)	0.8595
Black	1.164 (1.114, 1.216)	<0.0001
Other	1.136 (1.066, 1.211)	<0.0001
Unknown	1.081 (0.915, 1.268)	0.3519

Longitudinal Analysis:

Unplanned admission rates have risen for all patient populations since 2014 (Figure 3). Patients who were identified as Black consistently had higher rates of unplanned admission than patients who were identified as White, significant from 2015 academic year onwards (p range 0.003). Patients of Other race had significantly higher rates of unplanned admission from 2017-2019 academic years compared to White patients (p range 0.017). Additionally, relative to White patients, AIAN patients had a significantly higher admission rate in 2020 ($p = 0.012$) and Asian patients had a significantly lower rate in 2021 ($p = 0.044$).

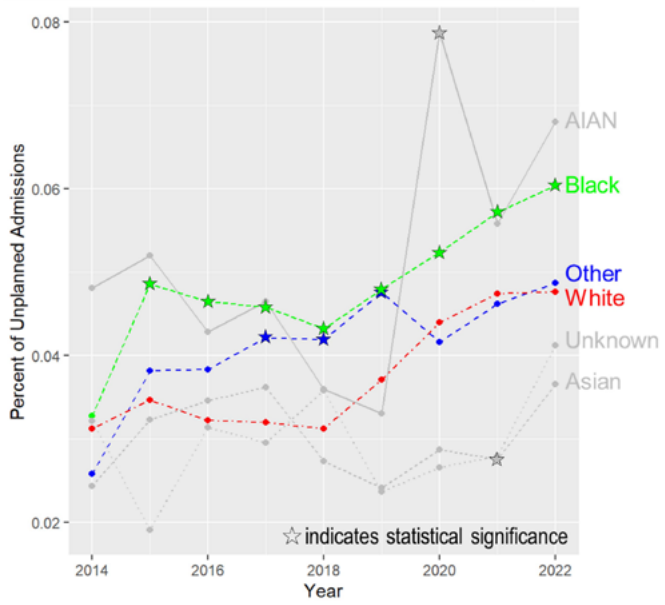

Figure 3. Unplanned Admission by Race and Academic Year. Data points that are statistically significant compared to White patients are starred. Unplanned admission rates have increased across all patient populations since 2014. Black patients have had higher unplanned admission rates than White patients since 2015 until the end of study period (p range ≤ 0.003). Compared to White patients, patients of Other race had higher admission rates from 2017-2019, AIAN patients had higher rates in 2020, and Asian patients had lower rates in 2021. AIAN = American Indian/Alaskan Native. Starred points indicate statistical significance.

ANOVA showed that unplanned admission rates were statistically different across the different academic years ($p < 0.001$). Under the assumption of linear change, results from logistic regression suggest that the overall odds of unplanned admission increased over time (OR 1.06, $p < 0.0001$). Again, under the assumption of linear change, results from logistic regression analyzing race and year interaction suggest that (1) compared with White patients, the odds of unplanned admission are higher for Black patients (OR 1.36, $p < 0.0001$) and Other (OR 1.18, $p = 0.0106$) across the years; and (2) the odds of unplanned admission increases over time for White patients (OR 1.07, $p < 0.0001$).

Discussion

Racial disparities in ambulatory surgery have been extensively documented. Janeway et. al found that access to ambulatory care is lower for Black and Hispanic patients compared to White patients, even after adjusting for age, comorbidities, insurance, income, and procedure.(1) Studies looking at specific specialties or certain procedures have also reported similar findings. Within otolaryngology, Gadkaree et. al found that the odds of receiving care in an ambulatory setting was significantly lower for Black and patients of non-specified other races than White patients, despite controlling for comorbidities, income, and urban-rural status.(4)

When looking specifically at cholecystectomies, Janeway et. al concluded that the odds of undergoing ambulatory versus inpatient cholecystectomy were significantly lower in Black and Hispanic patients.(5) In another common outpatient procedure, total joint arthroplasty, it was found that Black patients were less likely to undergo this procedure compared to White patients, which held when adjusted for age, gender, race, BMI, ASA, functional status, smoking, and comorbidities.(6) Even within the pediatric population, patients of racial/ethnic minority background were less likely to receive ambulatory surgical intervention; adjusted odds of surgery in an ambulatory location were lower for all racial/ethnic minorities compared to White patients, even after controlling for income, insurance, and health status.(7)

Our findings echo these previous studies and may potentially provide some explanation for bias in access to ambulatory surgery. Despite accounting for multiple previously identified risk factors,(3,8) our study shows that for much of the ambulatory population, patients who were identified as Black had a consistently higher rate of unexpected admission post-ambulatory surgery compared to patients who were identified as White. Only in ASA 4, and age groups 0-10 and 70+ were there no statistically significant differences when stratified by ASA and decade of life, respectively. This is likely due to medical comorbidities primarily driving unplanned admissions when categorized in ASA 4 and/or 70+ years old or more widespread Medicare coverage. In 0-10 age group, patients may be protected by the relative health of youth, Medicaid coverage, or less time exposed to social drivers of health.

The inconsistent significance of patients of other race could be due to our definition, given it includes patients of mixed race and those who identify as Latine. Some hypotheses for these findings include systemic level factors (structural racism, required insurance preapproval), socioeconomic status factors (transport/escort, social support, income), and physician/patient preferences.(1,5,7)

Initially we suspected AIAN patients were only found to have a significant increased rate of unplanned admission in ASA 2 due to the spread of the population within each ASA status. However, Supplemental Figure 1 demonstrates the distribution of ASA status was not vastly different between AIAN and White population (40.8% of AIAN population was classified as ASA 2, 44.4% of White population was classified as ASA 2). We also considered this could be due to the relatively smaller population size of AIAN (2,821 AIAN vs 219,071 White patients), though it is still considered statistically significant. The exact reason remains unclear.

Notably, unplanned admission rates began to rise for everyone in 2020, which is likely attributable to the COVID-19 pandemic (Supplemental Figure 2, illustrates increase in outpatient surgeries during study period but especially after 2020). Many patients delayed elective surgeries to avoid hospitalization and COVID-19 exposure. Likewise, any surgeries that could be pushed to the outpatient setting were done to create space, in addition to avoiding hospital exposure. The combined effect would mean more complex surgeries and sicker, more urgent patients in the ambulatory setting. Prior to the pandemic, unplanned admission rates were never above 4.0% (Supplemental Figure 3, visualizes overall rise of unplanned admission rate by academic year). However, 2020 onwards, unplanned admission rates were above 4.0% until the end of the study period.

Notably, in 2020, AIAN patients had a significantly higher unplanned admission rate compared to White patients, suggesting the COVID-19 pandemic may have disproportionately impacted the AIAN community. It is known that the pandemic was a major driver in the trend towards outpatient surgery. This may have pushed patients and providers to pursue outpatient surgery in cases that were suboptimal for the ambulatory setting. The pandemic likely also exacerbated existing reasons for unplanned admission, such as comorbidities, socioeconomic disadvantage, and reduced access to treatment(9), with effects echoing throughout the end of the study period.

Reasons for unplanned admission after ambulatory surgery are likely multifactorial, including social, organizational, anesthetic, and medical causes.(3) Previous literature has identified reasons for unplanned admission post-ambulatory surgery as mainly social/organizational (e.g., surgery ending after 3pm, unscheduled procedure, lack of escort or home support) and surgical (e.g., surgery length and type, unanticipated surgical complexity, post operative pain, fever, and/or bleeding).(2,3,8) The remaining unplanned admissions are accounted for by anesthetic (e.g., dizziness, post operative nausea and vomiting, inadequate level of consciousness, and urinary retention) and medical reasons (e.g., age, co-morbidities, and moderate to major illness severity).(3,8)

Unfortunately, sociodemographic barriers such as limited support networks at home immediately following surgery and lack of support following discharge are major contributors to unplanned admission,(4,5) and these challenges may disproportionately affect different population groups. Additionally, lack of paid time off work may push patients to pursue outpatient procedures versus a costly and timely hospital stay.(4,5) This emphasizes how thorough pre-operative screening and counseling may help avoid unplanned admissions. Differences in access to culturally competent care, variations in reimbursement, and physician bias may also play a role.

Given the study's retrospective design, we are unable to establish causality. Additionally, this is a single-center study from an academic, public institution in North Carolina. While the data are robust, the results may not generalize to other geographic regions or community-based settings with different case mixes or discharge practices. For reference, the University of North Carolina is a suburban tertiary care center that draws patients from all regions, from urban to rural areas, and has a wide range of socioeconomic levels within their patient population.

This study is also subject to documentation error and bias in observed versus patient-reported race. Although we encourage patient self-reporting of race/ethnicity, reporting is often left to the discretion of data source and thus may include observed race. Other possible confounding factors were not included in the database, such as ethnicity, reasons for admission, income, insurance status, socioeconomic status (via zip code-based proxies), comorbidity burden (Charleson Comorbidity Index), readmissions, and emergency department visits. Unfortunately, these data points were not included in our original data set and were unable to be accessed at the time of this project. Additionally, other unmeasured factors such as medical/surgical complexity, intraoperative complications/events, language preferences, and quality of provider interactions may influence findings. Lastly, there is unclear clinical significance as differences in unplanned admission rates are not large but do exist.

Ambulatory surgery is growing due to its cost-benefit and efficiency. However, groups that have been historically marginalized, particularly patients who are identified as Black, face disadvantages, even after adjusting for common predictors of unplanned admission. We acknowledge that without knowing whether these unplanned admissions were due to social, surgical, medical or anesthetic causes, the mechanisms driving disparities remain unclear. Thus, it is inappropriate to offer interventions aside from raising awareness of these disparities and conducting further investigations.

Nonetheless, identifying these worsening disparities will likely help inform future clinical practice and pre-operative planning. General recommendations at this time include encouraging more placements of patients on Enhanced Recovery After Surgery (ERAS) protocol(10), or other standardized protocols that help minimize unconscious and implicit bias in treatment. Future studies will include more variables, such as ethnicity, and focus on identifying the causes for unplanned admissions after ambulatory surgery to more effectively target preemptive interventions.

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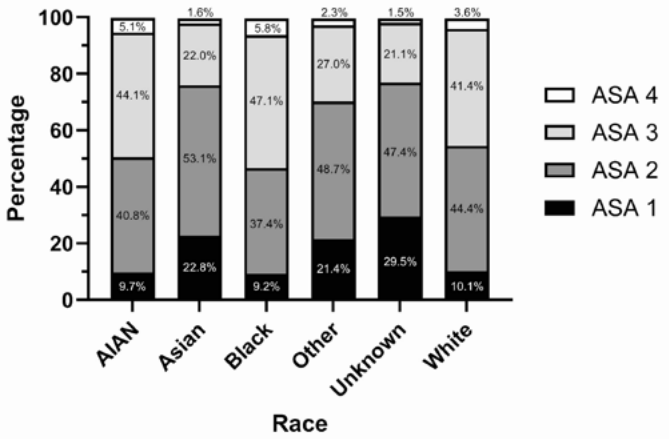
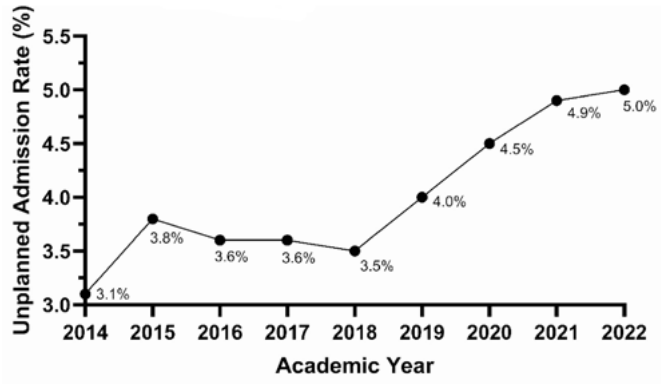
Supplemental Content

Supplemental Table 1 Multivariate Logistic Regression of Race and Unplanned Admission with BMI dropped. Adjusted with the following covariates: age, ASA status, gender, anesthesia start time (morning vs. afternoon), muscle relaxant use (yes vs. no), COVID-19 vaccination status, surgical specialty, and academic year. Results suggest that compared with patients whose reported race was White, patients reported as Black and Other have a statistically significant higher rate of unplanned admission. Unchanged significance from Table 2. AIAN = American Indian/Alaskan Native, CI = Confidence Interval.

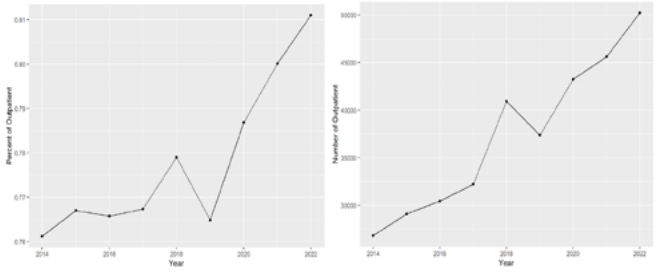
Race	Odds Ratio (95% CI)	P-value
AIAN	1.076 (0.901, 1.274)	0.4099146
Asian	1.035 (0.874, 1.215)	0.6862225
Black	1.167 (1.118, 1.218)	0.0000000
Other	1.114 (1.048, 1.184)	0.0005283
Unknown	1.031 (0.877, 1.204)	0.7097575



Supplemental Figure 1 Distribution of ASA Status by Race. The distribution of ASA status was not vastly different between AIAN and White population. Black patient population had a slightly higher proportion of patients classified as ASA 3 and 4 compared to White patients. Asian, Other, and Unknown had a higher percentage of patients classified as ASA 1 or 2 compared to White patients. AIAN = American Indian/Alaskan Native, ASA = American Society of Anesthesiologists (Physical Status).



Supplemental Figure 3 Overall Rise of Unplanned Admissions Rate by Academic Year. Academic year (labeled with beginning calendar year, beginning of July to end of June) was used. Notably, prior to COVID-19 (SARS-CoV-2) pandemic, unplanned admission rates were never above 4.0%. However, 2020 onwards, unplanned admission rates were above 4.0% until the end of the study period.



Supplemental Figure 2 Increase in Outpatient Surgeries 2014-2023 at the University of North Carolina at Chapel Hill. The number and percent of outpatient procedures has increased during this study's period from 2014-2023. This increase is particularly apparent after 2020, likely attributable to the COVID-19 (SARS-CoV-2) pandemic.

Predictors of Ambulatory Surgery Failure in General Surgery

MI Miñano-Sánchez[1], ML García-García[1,2], B Flores-Pastor[1,2], V Soria-Aledo[1,2]

Abstract

Background: Ambulatory Surgery (AS) is a care model designed to improve healthcare efficiency and resource utilization. However, unplanned overnight stays, hospital admissions and readmissions remain important challenges. This study analyzes causes and factors associated with AS failure in a secondary-level hospital.

Methods: We performed a retrospective, observational and analytical study including 3,397 patients who underwent AS in the Department of General and Digestive Surgery between 2023 and 2024. AS failure was defined as an unplanned overnight stay, hospital admission, or readmission within 30 days. Variables analyzed included age, sex, timing of surgery (day, month, year, morning/afternoon), procedure duration, healthcare area, surgical category and type of anesthesia. Bivariate analyses were performed and independent predictors were identified using multivariable logistic regression (Hosmer–Lemeshow goodness-of-fit test).

Results: Overall, 799 patients (23.5%) experienced AS failure: 470 overnight stays, 131 hospital admissions and 238 readmissions. Independent predictors of failure were longer procedure duration, placement of a central venous access device (DAVC), and use of general or spinal anesthesia. Protective factors included surgeries performed in March–April and procedures starting in the morning. Key adjusted estimates included: duration (OR 1.008 per additional minute; 95% CI 1.004–1.012), DAVC (OR 2.77; 95% CI 2.05–3.75) and general/spinal anesthesia (OR 2.38; 95% CI 1.99–2.86).

Conclusions: The AS failure rate in our series was 23.5%. Procedure duration, surgical category (notably DAVC placement) and anesthesia type were the main associated factors. Optimizing scheduling and perioperative planning may help reduce failure rates and improve organizational efficiency in ambulatory surgery programs.

Keywords: Ambulatory Surgical Procedures; General Surgery; Treatment Failure; Organizational Efficiency; Patient Readmission.

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Introduction

Understanding the reasons for ambulatory surgery (AS) failure is essential to optimize efficiency, reduce costs, and, above all, improve patient safety. By identifying clinical and organizational factors associated with unplanned admissions, this study aims to provide readers with practical insights to enhance the quality and sustainability of AS programs.

Ambulatory Surgery (AS) is an organizational and healthcare management model that has emerged in response to increasing surgical demand and growing waiting lists. Procedures considered suitable for AS are those that require low-intensity and short-duration postoperative care (1). AS implies that patients are discharged on the same day as the intervention without overnight hospitalization. Several discharge scoring systems are used to determine readiness for discharge; the modified Post-Anesthetic Discharge Scoring System (PADSS) by Chung is one of the most widely employed (2).

"Failure of the ambulatory surgery pathway" refers to situations in which the primary objective of AS—safe same-day discharge without complications requiring hospital admission—is not achieved. The main causes of AS failure can be grouped into clinical causes (e.g., uncontrolled pain, postoperative bleeding, persistent nausea or vomiting, urinary retention, fever), organizational causes (e.g., surgical delays, lack of observation beds, transport problems) and social/personal causes (e.g., absence of an escort for discharge, inadequate home conditions, or lack of confidence on the part of the patient or family).

Several studies have examined factors associated with AS failure. Advanced age has been identified as a risk factor for admission after ambulatory procedures (3). Female sex has also been associated with a higher risk of unplanned admission; for example, one study reported unplanned admission rates of 12.6% in women versus 6.9% in men (4). Likewise, scheduling (specific days of the week or time of day) can influence unplanned admission rates—interventions performed during non-working days or late hours have been suggested to increase the likelihood of unexpected hospitalization.

The type of anesthesia employed is a key factor related to AS failure in several publications. The chosen anesthetic technique directly influences the risk of immediate postoperative events (nausea, vomiting, pain, urinary retention, etc.) that may necessitate unplanned admission. General anesthesia has been associated with higher rates of unplanned admission, mainly due to postoperative nausea and vomiting, more intense pain and delayed recovery (5).

Accordingly, the primary aim of the present study is to analyze failure of the AS regimen in a secondary-level hospital. Secondary aims are to describe the sociodemographic characteristics of patients undergoing ambulatory procedures, to provide a descriptive analysis of the causes of AS failure, and to identify factors associated with such failures.

Material and Methods

This was a retrospective, observational, and analytical study of a case series of patients who underwent ambulatory surgery in a secondary-level hospital between 2023 and 2024.

Study population and inclusion criteria. Cases were identified through the hospital's Ambulatory Surgery registry. Eligible patients were 18 years, of both sexes, and underwent ambulatory procedures performed by the Department of General and Digestive Surgery. Interventions were categorized as abdominal wall, proctology, breast, central venous access devices (CVAD), soft tissue tumors (STT), or other procedures. Patients with incomplete records or who underwent surgery under an inpatient regimen were excluded.

Definition of ambulatory surgery failure. In our series, failure was defined as any situation in which the patient was not discharged on the day of surgery or required readmission within 30 days. We classified failure into three categories:

- Overnight stay: discharge occurring between 00:00 and 23:59 hours on the day following surgery.
- Hospital admission: patient did not meet the modified Chung PADSS discharge criteria and required inpatient admission of 2 days after surgery.
- Readmission: admission within 30 days of the procedure for any reason, whether directly related or not to the initial surgical process.

Variables analyzed. Failure of AS (overnight stay, hospital admission, or readmission) was assessed in relation to the following independent variables: age, sex, day, month, and year of intervention; healthcare area of residence; morning vs. afternoon session; duration of surgery; type of anesthesia; and surgical category (abdominal wall, breast, proctology, CVAD, STT, and others).

Statistical analysis. First, a descriptive analysis was performed to summarize the characteristics of the study population. Quantitative variables were expressed as mean and standard deviation or as median and interquartile range, according to distribution. Qualitative variables were summarized using absolute and relative frequencies. Second, bivariate analyses were conducted to explore associations between AS failure and each independent variable. Student's t-test or Mann–Whitney U test was used for continuous variables, while the chi-square test or Fisher's exact test were applied to categorical variables, as appropriate. Finally, multivariable logistic regression was performed to identify independent predictors of AS failure, with model calibration assessed using the Hosmer–Lemeshow goodness-of-fit test. Statistical analyses were conducted with SPSS version 21.

Results

Descriptive analysis. A total of 3,423 patients were identified in the hospital's clinical documentation registry. Twenty-six cases were excluded due to incomplete information, leaving a final sample of 3,397 patients.

The mean age was 53 years (range: 14–91 years). Males accounted for 64.4% of the study population.

Most surgeries were performed on Wednesdays and Thursdays, which together represented 48.3% of all procedures, whereas only 11% were performed on Fridays. The mean monthly surgical volume was 289 patients, with peaks in February, May, and October, and the lowest activity in August. No significant differences were observed between patients operated on in 2023 (48.8%) and 2024 (51.2%).

Regarding surgical category, 50.9% of patients underwent abdominal wall surgery, followed by proctology (23.3%), CVAD placement (8.4%), soft tissue tumors (6.6%), breast surgery (5.5%), and other procedures (5.2%).

Concerning anesthesia, spinal anesthesia was used in 49% of patients, local anesthesia and/or sedation in 42.2%, general anesthesia in 5.8%, and intravenous regional anesthesia in 3%.

By surgical session, 1,757 patients were operated in the morning and 1,640 in the afternoon. The mean procedure duration was 35 minutes.

When analyzing AS failure, 470 patients required overnight stay, 131 required hospital admission, and 238 were readmitted. The mean length of stay among readmitted patients was 11 days (95% CI: 8.7–13.2). Overall, 799 patients (23.5% of the total) experienced AS failure.

Bivariate analysis. After the descriptive analysis, we examined the association between ambulatory surgery (AS) failure and the independent variables (Table 1).

With respect to the day of surgery, Tuesdays and Thursdays showed the highest failure rates (25.9% and 25.6%, respectively), whereas Fridays had the lowest (15.2%). Regarding the month of surgery, February had the highest failure rate (28%), while April (16.2%), March (17.9%), and August (19.6%) showed significantly lower rates.

Table 1. Association between ambulatory surgery (AS) failure and sex, surgical category, type of anesthesia, surgical session, and year of intervention.

	Independent variables	AS Failure No	Yes	p-value
Sex	Male	1648 (75.4%)	539 (24.6%)	p= 0.038
	Female	950 (78.5%)	260 (21.5%)	
Surgical Category	Abdominal wall	1319 (76.2%)	411 (23.8%)	p<0.001
	Proctology	604 (76.2%)	189 (23.8%)	
	CDAD	183 (64%)	103 (36%)	
	STT	198 (88.8%)	25 (11.2%)	
	Breast	160 (85.6%)	27 (14.4%)	
	Other	134 (75.3%)	44 (24.7%)	
Type of anesthesia	Spinal	1199 (72.1%)	464 (27.9%)	p <0.001
	Local and/or sedation	1192 (83.1%)	243 (16.9%)	
	General	129 (65.5%)	68 (34.5%)	
	Intravenous regional	78 (76.5%)	24 (23.5%)	
Surgical Session	Morning	1518 (85.1%)	266 (14.9%)	p <0.001
	Afternoon	1080 (67%)	533 (33%)	
Year of surgery	2023	1203 (46.3%)	456 (57.1%)	p <0001

In terms of year, there was a significant decrease in AS failure between 2023 and 2024 (27.5% vs. 20%, respectively). Failure rates varied across age groups, with the highest rates observed among patients aged 41–60 years. A notable decrease in failure was observed in patients aged 60–80 years and in those younger than 21 years. Sex was also significantly associated with AS failure: 24.6% in men versus 21.0% in women.

No significant differences were observed according to healthcare area of origin ($p = 0.971$) or rural versus urban residence ($p = 0.798$). Surgical category was significantly associated with AS failure. CVAD procedures had the highest rate (36%), whereas breast surgery had the lowest (14.4%).

Anesthesia type was also relevant: general anesthesia had the highest failure rate (34.5%), followed by spinal anesthesia (27.9%). In contrast, local anesthesia with sedation showed a significantly lower rate (16.9%). Surgical session showed marked differences: morning procedures had a failure rate of 14.9% compared with 33.0% in afternoon procedures.

Finally, procedure duration was also associated with AS failure, with the highest rates observed in interventions lasting 21–40 minutes.

Multivariable analysis. A multivariable logistic regression was performed to identify independent predictors of ambulatory surgery (AS) failure (Table 2). The following factors were identified as independent predictors: Procedure duration: Longer surgeries were significantly associated with higher odds of AS failure (OR 1.008 per additional minute; 95% CI 1.004–1.012; $p < 0.001$). This indicates that, for every 10 minutes of additional operative time, the risk of failure increased by approximately 8%. Central venous access device (CVAD) placement: This category showed the highest risk, with an almost threefold increase in the odds of AS failure compared with other procedures (OR 2.77; 95% CI 2.05–3.75; $p < 0.001$). Anesthesia type: Use of general or spinal anesthesia was strongly associated with AS failure (OR 2.38; 95% CI 1.99–2.86; $p < 0.001$), more than doubling the risk compared with local anesthesia with sedation.

Table 2. Independent predictors of ambulatory surgery (AS) failure (multivariable logistic regression).

Independent variables	p-value	Odds Ratio	95% Confidence Interval (CI)
Procedure duration (per min)	,000	1,008	1,004-1,012
CVAD	,000	2,772	2,048-3,752
March/April (vs. other months)	,000	,596	,467-,760
General/spinal anesthesia	,000	2,384	1,985-2,863
Morning sesión (vs. afternoon)	,000	,331	,277-,394

Conversely, two factors were found to be protective: Month of surgery (March–April): Procedures performed during these months had significantly lower odds of AS failure (OR 0.60; 95% CI 0.47–0.76; $p < 0.001$). Morning procedures: Operations scheduled in the morning session were associated with a substantial reduction in failure risk (OR 0.33; 95% CI 0.28–0.39; $p < 0.001$). These results suggest that both surgical and organizational factors play a key role in determining the success of AS programs. Optimizing patient selection, anesthetic management, and operating room scheduling could significantly reduce the rates of unplanned admissions, overnight stays, and readmissions.

Discussion

In this study, we analyzed 3,397 patients undergoing ambulatory surgery (AS) in a secondary-level hospital, of whom 799 (23.5%) experienced AS failure, defined as unplanned overnight stay, hospital admission, or readmission. This rate is higher than those reported in many published series, although the discrepancy may be partly explained by differences in the operational definition of failure across studies.

Our analysis identified several independent predictors of AS failure. Longer procedure duration was strongly associated with increased risk, highlighting the importance of careful selection of cases suitable for AS and efficient surgical planning. CVAD placement emerged as the category with the highest failure rate, which may reflect the specific characteristics of these patients, often older, immunocompromised, or already hospitalized, and in whom discharge is commonly delayed for clinical or logistical reasons.

Anesthetic technique also had a major impact. General and spinal anesthesia were both associated with a markedly higher risk of AS failure compared with local anesthesia with sedation. This finding is consistent with the physiological side effects of these techniques, including postoperative nausea and vomiting, urinary retention, prolonged recovery, and delayed mobilization, which may hinder same-day discharge.

In contrast, two protective factors were identified: procedures scheduled in the morning session and those performed in March–April. Morning surgery likely allows more time for postoperative observation and management of complications before the end of the day, facilitating same-day discharge. The seasonal effect observed in March–April may reflect organizational factors, such as higher operating room efficiency or resource availability, although further studies would be needed to confirm this association.

Overall, these findings underscore that both clinical (surgical complexity, anesthesia, duration) and organizational (scheduling, resource allocation) variables significantly influence the success of AS.

Our observed failure rate of 23.5% is higher than most reports in the literature, which often describe rates ranging between 5% and 15% (6). However, this variability is largely due to heterogeneous definitions of "failure." While some authors only consider hospital admission or readmission, we also included overnight stays, which increases sensitivity but also raises the apparent rate.

The influence of age and sex has been variably reported. In our series, men had a higher failure rate, consistent with some authors (8), although others have reported the opposite (9). This discrepancy suggests that demographic factors may be less relevant than clinical or organizational determinants.

Our results confirm that spinal anesthesia remains the most frequently used technique in AS in our setting, but it also showed the highest failure rate. This aligns with previous reports indicating that spinal anesthesia, especially when long-acting agents are used, can prolong recovery and delay discharge (10). Conversely, local anesthesia with sedation has consistently been associated with faster recovery, lower complication rates, and greater feasibility in ambulatory settings, making it a safe and effective alternative (11).

Procedure duration has also been recognized in several studies as a risk factor for AS failure (12). Our findings are consistent with this evidence and reinforce the recommendation to restrict longer or more complex procedures to settings with adequate postoperative monitoring or even inpatient care.

Regarding surgical category, abdominal wall surgery was the most frequent, consistent with other series (12). CVAD placement, however, was the procedure most associated with failure, in line with prior publications describing this population as higher risk due to age, comorbidities, and immunosuppression (13).

Taken together, our results support the need for ongoing evaluation of AS programs, considering not only patient-related and surgical factors but also organizational aspects such as scheduling and resource allocation.

Future prospective and multicenter studies are needed to validate these results and to further explore the impact of social and organizational factors on AS failure. Such studies would help to design targeted strategies for improving patient pathways and consolidating the role of AS as a safe and efficient model of surgical care.

This study has several limitations. First, its retrospective design makes it dependent on the quality and completeness of medical records. Second, it was conducted in a single center, which may limit the generalizability of the results. Third, we did not include certain potentially relevant variables, such as functional status, comorbidities, or social factors (e.g., family support, living conditions), which can also influence the likelihood of unplanned admission. Fourth, the operational definition of AS failure used in this study may not be fully comparable with those of other publications, complicating direct comparison of failure rates. Finally, we were unable to specifically classify failures according to clinical, social, or organizational causes, which would have provided additional insight into the reasons for unplanned admissions.

The originality of our work lies in analyzing a large patient cohort from a secondary-level hospital while simultaneously considering both clinical and organizational factors. Few studies have assessed the influence of operating room scheduling (morning vs. afternoon) or calendar effects on AS outcomes, making our findings particularly relevant for resource planning and efficiency optimization.

Conclusion

In our series of 3,397 patients, nearly one in four experienced failure of ambulatory surgery. Longer procedure duration, CVAD placement, and the use of general or spinal anesthesia were the strongest predictors of failure, while morning scheduling and specific calendar periods reduced risk. These findings highlight the importance of optimizing patient selection, anesthetic strategy, and organizational planning to improve the safety and efficiency of ambulatory surgery programs.

Our findings may guide practical interventions in operating room scheduling, patient selection, and anesthesia planning to reduce unplanned admissions and improve the performance of AS programs.

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Injectomat versus Infusomat in Day Surgery. A prospective, mixed-methods observational project, investigating which procedure is most sustainable

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Abstract

Background: Anaesthesia procedures can impact both environmental sustainability and the physical health of healthcare professionals. At Aarhus University hospitals Day Surgery Department, nurse anaesthetists reported finger pain and discomfort associated with frequent manual syringe preparation using injectomat. The aim was to compare the environmental impact, cost, and ergonomic workflow of two anaesthesia delivery procedures: injectomat (syringe pumps) or infusomat (drop counters).

Method: We conducted a prospective, mixed-method observational study over 16 weeks, to investigate the difference of the two anaesthesia procedures. Anaesthesia nurse (n = 22) alternated between using injectomat and infusomat in two 8 week periods. Quantitative data were collected via daily utensil logs and the Disabilities of the arms, shoulders and hands questionnaire at weeks 1, 4, and 8 of each period. Life Cycle Assessment was used to calculate the CO_{2e} emissions of the utensils involved. Semi-structured interviews were conducted for qualitative insight.

Results: Using infusomat reduced the daily amount of utensil used by 41,6%, resulting in a 13,6% cost reduction and a 33,42% decrease in CO_{2e} emissions. Disabilities of the arms, shoulders and hands scores improved by 25,97% in week 1, 12,8% in week 4, and 25% in week 8 during the infusomat period. Interviewed nurse anaesthetists reported significantly less strain on hands and fingers.

Conclusion: Infusomat offer a more sustainable alternative to injectomat in anaesthesia for short procedures. They reduce utensil consumption, lower CO_{2e} emissions, and improve nurse anaesthetists' physical comfort. Further research is recommended in settings with longer procedures to assess generalizability and long-term effects.

Keywords: anaesthesia, Carbon footprint, cost- effectiveness, sustainability, work environment.

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Introduction

Approximately 10,000 patients undergo surgery each year at the Day Surgery Department, Aarhus University Hospital, Denmark. This department covers a range of surgical specialties, including gastroenterology, orthopaedic, gynaecology, urology, neurology and ear, nose and throat surgery. To facilitate these surgeries, most patients are placed under general anaesthesia. Some patients receive general anaesthesia combined with a regional block, while a few short interventions are performed in local anaesthesia. In our department, propofol and remifentanil are the primary medical agents used for the anaesthesia.

The idea behind the study originated from reports by anaesthesia nurses who experienced significant finger pain and stiffness, in some cases from bending their fingers. Combined with the global focus on climate change, which is the biggest threat towards the global health, motivated us to explore ways to address both ergonomics and environmental concerns (1). Hospitals emit large quantities of carbon dioxide (CO_2 emissions), leading to increasing international consensus documents advocating for the reduction of utensil use, medication waste, and general hospital waste (2, 3).

This study evaluates an alternative procedure for administering anaesthesia medications with consideration for environment, workflow, and cost. Traditionally, anaesthesia medications are delivered using syringe pumps (Injectomat). In this study, we tested the use of drop counters (Infusomat) as an alternative.

To our knowledge, only one study has previously investigated the reuse of utensils in surgical settings, and it did not involve infusomat. Karlsson et al. tested the reuse of syringes between patients and found no significant risk of bacterial contamination (4). An older study also reported no contamination risk when using two anti-reflux valves (5). However, it is important to note that while the pharmaceutical companies recommend single use for the syringe and drop set, hospital specific protocols, if approved by the medical management and hospital's infection control nurse, may already allow reuse of syringes for injectomat (6). Implementing the infusomat procedure would similarly require the creation and approval of a new reuse protocol for the infusomat drop sets.

This study aimed therefore to evaluate and compare the two procedures with respect to ergonomic workflow impact on the hands, fingers, elbows, and shoulders, the consumption and cost of medical utensils, and to investigate which procedure was more sustainable from an environmental perspective measured in CO_2 emissions.

Materials and Methods

The study was conducted at the Day Surgery Department, Aarhus University Hospital (AUH), Denmark, between mid-August 2024 and March 2025. Prior to the study initiation, the nurse responsible for clinical development held an information meeting for all staff involved. This meeting provided details about the objectives and

procedures, and distributed project folders containing relevant information.

To introduce the infusomat, the anaesthesia nurses received training on their use from a representative of the pharmaceutical company supplying the infusomat.

Inclusion
All anaesthesia nurses and anaesthesia nurse students employed at the Day Surgery Department, AUH, was invited to participate.

Exclusion
All anaesthesia doctors were excluded from the study, as medication preparation is not a primary component of their primary responsibilities.

The two procedures
Using either one of the procedures we change the intravenous drop set and the double barrelled medical kit, also called the double run Total Intravenous Anaesthesia set (TIVA set), between every patient. Therefore, no counting concerning that. But the rest of the utensils varied according to which procedure was in use (Figure 1).

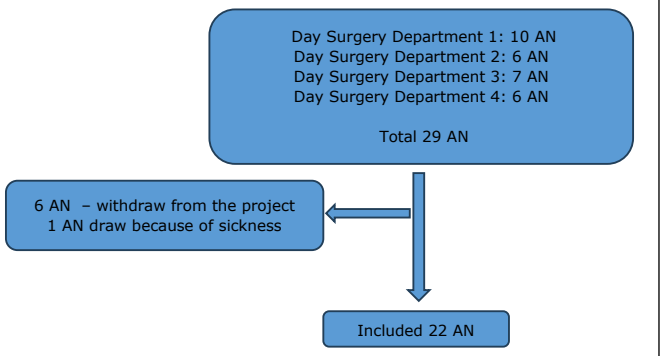

Figure 1. Flowchart of the inclusion of the anaesthesia nurses .

Injectomats
The injectomats are the most traditionally procedure used, and the 60 ml syringes for the injectomats are manually drawn by the anaesthesia nurse, for the anaesthesia medications (propofol and remifentanil). When a syringe empties, an alarm sounds and a new syringe must be drawn up and attached. These syringes are then loaded into the Injectomats. This manual, repetitive syringe filling process is physically demanding and places significant strain on the hands and fingers of the nurses. Our department don't have prefilled syringes so all filling is carried out manually by the anaesthesia nurse.

Infusomats
When using infusomat, anaesthesia medications are prepared by connecting medication bottles to a drop set that is attached to the infusomat. This setup is prepared in the morning during the surgery room setup. During the day, when a bottle empties, the anaesthesia nurse simply replaces it by attaching a new bottle to the existing drop set. This method eliminates the need for manually drawing up medications into syringes, thereby potentially reducing strain on the hands and fingers and decreasing the consumption of single use utensils. If correct hygiene protocols are observed, the same drop set may be used for up to eight hours (7, 8).

Study Design
A prospective mixed method observational study was conducted over 16 weeks.

To evaluate which procedure provided the most ergonomic workflow, the study was divided into two consecutive eight week periods. During the first period, anaesthesia nurses used injectomat as the traditional method. Following the introductory training, the anaesthesia nurses switched to using infusomat for the subsequent eight weeks. Throughout the full 16 weeks, participants completed two types of schedules and questionnaires, which were stored in individual project folders. Finally, to each eight week period, a semi structured focus group interview was conducted by a work environment representative.

The ergonomic workflow
To examine the ergonomic workflow, we used the questionnaire "Disabilities of the arms, shoulders and hands" (DASH), validated in Danish (9). The DASH questionnaire was developed in 1996 by the American Association of Orthopaedic Surgery (AAOS) and the Institute for Work & Health (Toronto)(10). It is a validated, sensitive and reliable questionnaire, shown to be quick and easy to answer (11).

It is a self-reported questionnaire with 30 items, each with five possible answers. The 30 questions are divided into: 21 of questions concern the functionality of daily living activities; 5 questions specifically concerns symptoms as pain, weakness, stiffness and sensitivity and the last four questions covers professional and social activities (10, 12).

For calculating the DASH score a mathematical formula is used. The score extends from 0-100; 0 is no disabilities and 100 is maximum disability (11).

The anaesthesia nurses scored the DASH three times during both the injectomat and the infusomat period; 1. week, 4. week and 8. week, in total 6 times.

Qualitative Interviews
Focus group interviews was conducted to get a description of the anaesthesia nurses ergonomic workflow using the two procedures, and if and how the two procedures affects their hands, fingers or shoulders. A work environment representative conducted the interviews and the analysis.

Usage of utensils and sustainability
To record the use of utensils, and thereby the carbon footprint, associated with the two procedures, we developed a registration schedule, where the anaesthesia nurses registered their daily use of utensils, during both periods.

The Centre for Sustainable Hospitals calculated the Life Cycle Assessment (LCA) for each utensil. LCA is a method used to evaluate the environmental impact and resource consumption associated with products or services. This comparative study is calculated by CO_{2e} emissions and with a cradle-to-grave approach which includes the stages from raw material extraction to disposal (13).

Pricing information for each utensil was obtained from the Aarhus University Hospital purchasing department as of June 2024 and is presented in Danish kroner (DKK). To respect confidentiality agreements with medical suppliers, only the total costs are reported. Prices are listed in table 1 based on March 2023 rates (Table 1).

Analysis
The manual utensil schedules and the DASH scores were collected after the 16 weeks. The total and average usage of utensils, along with the DASH scores, were calculated and analysed.

Ethical Approval
Ethical approval for this study was not required because, it does not involve experiments on humans or animals. The investigation of the new work-related procedure falls outside the Ethical Committees jurisdiction.

Table 1. The utensils used to start up the day for either the injectomat and the infusomat.

Injectomat			Infusomat			
Number	DKK	CO_{2e}	Utensils	Number	DKK	CO_{2e}
2	-	384,7	60 ml syringes	0	-	-
2	-	88,6	Spike	0	-	-
1	-	51,9	Anti reflux valves	1	-	51,9
1	-	104,5	Transfer needle	1	-	104,5
0	-	-	Infusomat drop set	2	-	416,6 (long)-341,5 (short)
6	32,97	1103	Total	4	40,69	989,6 (long) – 839,4 (short)

Results

A total of 22 the anaesthesia nurses participated in the study. Initially, 29 the anaesthesia nurses were enrolled; 6 withdrew due to difficulties with the infusomat, 1 never got started registering because of sickness. So, we ended up with 22 anaesthesia nurses for analysis (Figure 1).

The ergonomic work flow

The overall results from the DASH score showed a clear tendency towards improved ergonomic work flow when using Infusomats instead of Injectomats.

However, only 7 out of the 22 anaesthesia nurses completed the DASH questionnaire at all six times. Therefore, instead of calculating a total score, we calculated the average scores for those anaesthesia nurses who completed the questionnaire at the same time points during each period. During both procedures 10 anaesthesia nurses had scores the 1st-week; 12 the anaesthesia nurses had scored the 4th- week and 10 anaesthesia nurses had scored the 8th.

Compared the anaesthesia nurses scored (Table 2):

The 1st week 7,7 (injectomat) and 5,7 (infusomat)

The 4th week 7,8 (injectomat) and 6,9 (infusomat)

The 8th week 6,8 (injectomat) and 5,1 (infusomat)

This corresponds to a **25,97 % reduction** in the DASH score at the 1st-week scoring when comparing the infusomat period to the injectomat period.

At the 4th-week scoring, a **12,8 % reduction** was observed, and by the 8th week, the DASH score showed a **25 % reduction** after the anaesthesia nurses had switched from injectomat to infusomat (Figure 2).

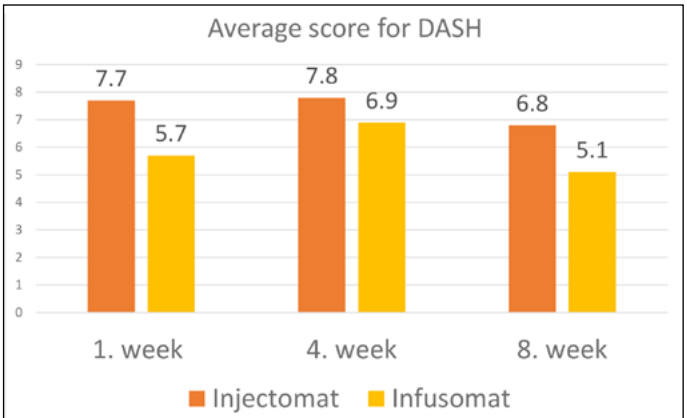

Figure 2. The DASH average results compared for the injectomat and the infusomat period.

Interview results

A total of 11 anaesthesia nurses participated in the interview following the injectomat period, and 5 anaesthesia nurses participated in the interview after the infusomat period.

In response to the question **"What are your ergonomic challenges when using the injectomat?"**, the anaesthesia nurses, after 8 weeks of using the injectomat, reported:

- *"Pain in my thumb, all the way into my hand."*
- *"It is hard to pull up the syringes."*
- *"No pain, but I can feel that it loads up, particularly in the thumb."*

When asked the same question after 8 weeks of using the Infusomats, the anaesthesia nurses responded:

Table 3. The results of the used amount of utensils during the injectomat and the infusomat period.

	Injectomat (n= 345)				Infusomat (n =339)		
Utensils	Amount	Price	CO_{2e}	Utensils	Amount	Price	CO_{2e}
60 ml Syringes	1926	3967,56	323568	60 ml Syringe	90	185,4	15120
Spike	1216	12001,92	94604,8	Spike	288	2842,56	22406,4
Anti reflux valves	1010	3151,2	23634	Anti reflux valves	1.168	3644,16	27331,2
Transfer needle	830	4971,7	80676	Transfer needle	708	4240,92	68847,6
Infusomat drop set	0	0	0	Infusomat drop set	604	9537,16	208133,4
Total	4982	24092,38	522482,8	Total	2858	20450,2	341838,6
Pr. patient	**14,44**	**69,83**	**1.514,44**	**Pr. patient**	**8,43**	**60,33**	**1.008,37**
Percentage difference				**Percentage difference**	**-41,6%**	**-13,6%**	**-33,42%**

Table 2. The DASH scoring for the AN for both the injectomat and the infusomat period.

	Injectomat			**Infusomat**			
Nurse	1.	2.	3.	Nurse	1.	2.	3.
a.	8,62	3,45	12,07	a.		6,9	5,17
b.				b.			
c.	6,89	6,03	12,06	c.	5,17	6,89	4,31
d.				d.	0	0	0
e.	18,1			e.	0		
g.	3,45		2,58	g.			
h.	0	0,89	0,86	h.	0,86	0,86	0
i.	0	1,72	0	i.		0	0
j.	12,93	17,24	26,72	j.	35,34	20,7	14,66
k.				k.			
l.		6,8	5,17	l.		1,72	4,31
m.	0,86	0	0	m.	0	0	18,75
n.	21,55			n.			
o.				o.			
p.	1,72	1,72	1,72	p.	0	0	0
q.	2,59	2,59	2,59	q.	2,59	0	0
r.	30,17	35,35		r.		44,83	41,38
s.	7,14	6,9	6,9	s.	6,9	1,67	4,31
t.	13,79	12,93	6,03	t.	6,03		
u.				u.			
v.	12,93	11,2	0	v.	0	0	
x.				x.	5,17		
22 In total	**76,94 á 10**	**93,89 á 12**	**68,09 á 10**	**22 In total**	**56,89 á 10**	**83,57 á 12**	**51,51 á 10**
	7,7	**7,8**	**6,8**		**5,7**	**6,9**	**5,1**
Percentage difference					**25,97 %**	**12,8 %**	**25 %**

- *"It is nice — less load because pulling up the syringes has stopped."*
- *"The workflow has become more flexible and quick."*
- *"It takes longer time during the mornings — up to 10–20 minutes."*

The work environment representative concluded:

"Using infusomat instead of injectomat, it was unambiguously clear that the interviewed anaesthesia nurses experienced a noteworthy reduction in physical strain, particularly regarding their fingers, hands, elbows, and shoulders."

Usage of utensils and sustainability

Using the injectomat was registered for 345 days and pr. day calculation showed, an average of 14,44 utensils , the cost amounted to 69,83 DKK and the CO_{2e} emissions totalled 1514,44 grams (Table 3).

Using the infusomat was registered for 339 days and pr. day calculation showed, an average of 8,43 utensils, the cost amounted to 60,33 DKK and the CO_{2e} emissions totalled 1008,37 grams (Table 3).

The results demonstrated that switching to infusomat led to a **41,6% reduction** in the number of utensils used per day, a 1**3,6% cost reduction**, and a **33,42% decrease** in daily CO_{2e} emissions (Table 3).

Discussion

The combined results from the DASH scores and the interviews indicate that the ergonomic flow on anaesthesia nurses' fingers, hands, elbows, and shoulders reduced when using infusomat instead of injectomat. Additionally, the utensil counts show a clear trend towards a reduction in utensil consumption, overall cost, and CO_2 emission.

However, not all anaesthesia nurses participated in the interviews, introducing a potential selection bias. It is uncertain whether those who did not attend were anaesthesia nurses without problems who found it unnecessary, or those with severe discomfort who were reluctant to come forward. This makes it difficult to determine if the interviewed participants are representative of the entire ergonomic workflow group. Furthermore, not all anaesthesia nurse completed the DASH questionnaire. This could be due to forgetfulness or perceptions that the questionnaire was unnecessary. The missing scores could introduce information bias in either direction: a low score might underestimate the difference between the two procedures, while a high score might exaggerate it. It is also possible that the manual registration of utensil use was not entirely accurate. The anaesthesia nurses were responsible for recording utensil use throughout their busy day, and some utensils may not have been consistently documented. However, this potential underreporting would likely affect both procedures equally, minimizing its impact on comparative results.

Despite these limitations, the data strongly suggest that using infusomat instead of injectomat in a Day Surgery setting improves ergonomic workflow for anaesthesia nurses.

Three challenges arose during the project, some of which we had not anticipated despite conducting a pilot study. These challenges included 1. A new workflow: Adjusting to the infusomat system required time and training. 2. Occlusion alarms: Alarms occurred more frequently with the infusomat setup than with the injectomat. 3. Hygiene concerns: Strict protocols had to be followed to maintain hygiene standards when reusing infusomat components.

A new workflow

Preparing the infusomat in the morning initially took 10–20 minutes longer compared to the injectomat. Those infusomats we had were more sensitive than the injectomat, making it essential to be precise when setting up the drop sets. To support the anaesthesia nurses, we developed pocket sized guidelines containing setup instructions and troubleshooting tips.

Despite the initial adjustment period, one anaesthesia nurses stated during the interviews after using the Infusomats for eight weeks: "This gives more time for observation and patient care." This suggests that, the time used in the morning preparation, are saved during the day, not having to prepare new syringes, between patients or during the surgery. Also, over time, as the setup becomes more familiar, morning preparation may become quicker and integrate naturally into the daily workflow.

Occlusion alarms

At the beginning of the project, we experienced unexpected occlusion alarms, particularly when administering bolus doses. This created an unsafe situation, and as an immediate safety measure, each anaesthesia nurse kept a syringe with 20 ml of propofol readily available. We initially inspected the infusomat preparation and setup for any errors but found no faults. Subsequently, we turned our attention to the patient side of the system.

We identified the problem; the double run TIVA-set and the drop set with two three-way taps required the medication to pass through a very narrow lumen distal to the double run TIVA-set. This likely contributed to the increased resistance and triggered the occlusion alarms.

To address the issue, we replaced the double run TIVA-set with two separate thin extension lines and a drop set equipped with three three-way taps. This modification maintained the flexibility of having additional medication access during anaesthesia while significantly reducing flow resistance — effectively resolving the occlusion alarm problem.

Hygiene

With the injectomat, the protocol was to remove the syringe between patients and clean the device (6). In contrast, with the Infusomats, the drop set remains in the Infusomat between patients, while the double run TIVA-set set is changed after each patient.

Using the infusomat the drop set to the infusomat is approved to be used up to 12 hours, in another hospital in Denmark, and the pharmaceutical company approves the use op to 24 hours (7, 14). In our Day Surgery Department, we use the same infusomat drop set during the dayshift, for 8 hours.

It is therefore important to note: if the infusomat drop set becomes contaminated and must be changed between all patients, the procedure would no longer be cost effective, environmentally friendly, or ergonomically advantageous. As listed in table 3, it is clear that the infusomat sets are the most expensive utensil pr. piece, therefore it is important to secure the cost effectiveness that one infusomat set is used as long as possible, max 12 hours (Table 3). (near here).

Also, looking at the CO_2 emission, the setup for the Infusomat almost has the same CO_2 emission as the setup for the injectomat, so have to replace a new infusomat drop set between each patient will make the procedure not environmentally friendly (Table 1).

It takes extra time setting up the infusomat drop set, and if cannot be used for a day extra time has to be in calculated, and thereby more twist and turns will be added, and the ergonomically advantageous will fade.

During the project, we only had access to a long infusomat drop set, which increased the risk of contamination if the lines touched the patient or the floor. To manage this, we rolled up the long line from the infusomat drop set and collected it in a small plastic bag, which was changed between every patient.

However, after the project, a pharmaceutical company produced a shorter infusomat drop set, eliminating the need for the small bag, simplifying the setup, and further improving workflow, hygiene and CO_{2e} emission (Table 1) (7, 8, 15-17).

A detailed hygiene instruction was developed and implemented to ensure that all staff followed correct procedures, maintaining patient safety throughout. However, a Swedish study from 2024 concluded that no risk of bacterial contamination was found when reusing syringes with two anti-reflux valves and changing only a 10 cm infusion line between patients (4). In our setup, we changed the entire double run TIVA-set , over 100 cm long, between each patient. Therefore, we believe that the risk of cross contamination between patients in our study setup is minimal.

Conclusion

Our study concludes that using infusomat instead of injectomat improved the ergonomic workflow for anaesthesia nurses, with up to a 25% reduction in physical strain on hands, fingers, elbows, and shoulders, after using infusomat for eight weeks.

In addition, we demonstrated substantial environmental and economic benefits with a reduction of 41,6% in the use of utensils, a 33,42% reduction in CO_{2e} emissions, and a 13,6% overall improvement in cost effectiveness.

Thus, infusomat represent a more sustainable, ergonomic, and cost efficient alternative to injectomat in a Day Surgery setting.

Perspective

This study was conducted in a Day Surgery setting characterized by many short operations throughout the day. However, the use of infusomat may also be beneficial in stationary surgery rooms where longer procedures are performed. We have no calculation towards that, but starting the day, making the infusomat setup, and only have one or two patients there will only have to be change utensils once having two patients. Using the injectomat the anaesthesia nurses has to draw up all syringes and use spikes and transfer needles as well, during the surgery and between patients (Table 2).

In such settings, starting the day with a complete setup, and only needing to change the medication bottles during the day, could further amplify the reduction in utensil use and CO_{2e} emissions, given the lower patient turnover.

The ergonomic benefits for the anaesthesia nurses could similarly be expected to continue or even improve.

However, additional studies are necessary to investigate whether the economic and ergonomic benefits observed in this study are consistent in settings with fewer, but longer, surgical procedures.

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Reaffirming Patient Positioning as a Foundation of Airway Management in Ambulatory and NORA Settings

Gayes JM

Abstract

Patient positioning remains a fundamental pillar of airway safety across both OR and NORA environments. Airway safety discussions increasingly emphasize new technologies and difficult□airway algorithms, yet the foundational role of patient positioning remains underrepresented. Successful airway management depends not only on technical proficiency but also on pre-planned, optimal alignment of the head, neck, and torso prior to laryngoscopy. Proper positioning improves preoxygenation, prolongs safe apnea time, and increases first-pass intubation success across both operating room (OR) and non-operating room anesthesia (NORA) environments. As NORA cases expand, often involving older and more medically complex patients, environmental constraints further heighten the importance of positioning readiness. Even with advanced video-laryngoscopy devices, positioning remains a key determinant of safety. This viewpoint reaffirms patient positioning as a core airway skill that must be explicitly taught, emphasized, and referenced in educational materials and clinical publications. Recognizing positioning as a proactive component of airway preparedness will strengthen patient outcomes and sustain the core competencies of anesthesia practice..

Keywords: Patient positioning, Airway management .

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Key Points:

- Patient positioning is a fundamental skill and key element for airway safety in both the OR and NORA's.
- This core skill is frequently overlooked when airway safety is referenced.
- Optimized upper body positioning can improve the apneic reserve and airway management success.
- Favorable positioning will facilitate all methods of airway management.

The advent of newer intubating assist devices have influenced algorithm pathways for difficult airway management and prompted renewed discussions of airway safety. However, in these valuable discussions of airway safety in both the operating room (OR) and non-operating room anesthesia (NORA) settings, an essential component often receives insufficient emphasis.

A 2022 APSF update emphasized the time-sensitive nature of hypoxemia and the critical role of preoxygenation strategies in extending the safe apnea period (1). The head-elevated laryngoscopy position (HELP) has been shown to improve oxygenation and extend safe apnea time by reducing the onset of hypoxia, thereby providing essential latitude during airway instrumentation (2-5). Positioning is therefore not a passive preparatory step but an active, evidence-based intervention that directly influences airway safety.

The ASA Difficult Intubation Algorithm and related guidelines underscore that readiness is a defining component of maintaining core airway skills (6). Airway difficulties often arise unexpectedly and demand immediate response. Devices should be readily available, and patient positioning should be viewed as a pre-planned "tool" applied before laryngoscopy begins, not corrected reactively after difficulty has begun. When proactively optimized, positioning enhances readiness, shortens time to intervention, and reduces peri-intubation complications.

Nearly half of all anesthetics in the United States now occur in NORA environments, including GI endoscopy, interventional radiology, cardiac catheterization, and procedure suites (7-8). These patients tend to be older, medically complex, and more physiologically vulnerable than their OR counterparts (7-8). Notably, NORA environments account for a disproportionate number of closed claims, with GI suites representing a major source of airway-related events (7-9).

Environmental and ergonomic challenges such as non-articulating tables, limited head access, awkward room configurations, reliance on deep sedation, and reduced staffing, frequently limit optimal airway alignment in these ambulatory settings. Given the frequent use of deep sedation, particularly in obese patients or those with comorbidities such as obstructive sleep apnea (OSA), inadequate head and neck positioning contributes significantly to respiratory complications. Failure to position the head and neck correctly is a common and preventable contributor to critical events. Malpractice claims related to respiratory events comprise 30–40% of NORA claims, nearly double the rate observed in traditional operating rooms (10). Optimal head-elevated positioning improves oxygenation, enhances laryngoscopy view, and decreases the risk of hypoxemia during both sedation and intubation. Emergency airway management literature reinforces that positioning is integral to intubation success and complication reduction (11,12). Positioning is not only a technical maneuver but a readiness skill that influences every phase of airway management, from preoxygenation and mask ventilation to first-pass intubation success and rescue strategies. The omission or under-representation of positioning represents a critical gap in airway safety education, particularly in ambulatory and NORA environments where ergonomic limitations and patient complexity compound risk.

Video-laryngoscopy (VL) has improved first-pass success in many settings, including critical care (13). However, concerns persist regarding the potential "deskilling" of direct laryngoscopy skills among anesthesia professionals (14). These technological advances should not obscure a key physiologic truth: proper alignment improves success across all airway techniques, including mask ventilation, VL, direct

laryngoscopy, supraglottic airway placement, and emergency rescue pathways (15-20). When synergistically combined with modern airway devices, optimal positioning substantially increases first-pass success. The omission or under-representation of positioning represents a critical gap in airway safety education, particularly in ambulatory and NORA environments where ergonomic limitations and patient complexity compound risk.

Repeated laryngoscopy attempts worsen outcomes and decrease subsequent success rates, as shown in multicenter intubation studies (21,22). The ASA guidelines recommend limiting attempts to three or fewer whenever possible (6). Obesity, OSA, and increased neck circumference further amplify risk (23-25). ASA Closed Claims analyses show that 68% of difficult intubation claims involve obese patients (25). Across ambulatory and NORA settings, where obesity and OSA are common, head/neck/upper torso positioning plays a pivotal role in risk reduction.

Conclusion

Patient positioning remains a fundamental pillar of airway safety across both OR and NORA environments. As anesthesia delivery increasingly transitions to ambulatory and procedural locations, the importance of head-elevated and well-aligned positioning becomes even more pronounced. Its role as an early, indispensable, and modifiable airway skill warrants deliberate emphasis in future publications, guideline updates, training curricula, and clinical practice.

Reaffirming positioning as a foundational element of airway management is essential not only for optimal procedural success but for safeguarding patients in environments where airway risks are heightened and resources may be limited.

Conflict of Interest

James M. Gayes, MD is the founder of OPAD Airway Inc., a start-up medical device company. Dr. Gayes is co-inventor on patents covering an inflatable patient adjustment device and has equity in the company but does not receive any personal or professional financial renumeration. The company has no current commercial product.

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