Regional Anesthesia and Pain

Increased body mass index and ASA physical status IV are risk factors for block failure in ambulatory surgery - an analysis of 9,342 blocks

[Un indice de masse corporelle élevé et un état physique de classe IV selon l'ASA sont des facteurs de risque d'échec de l'anesthésie régionale ambulatoire – l'analyse de 9 342 cas]

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Purpose: Regional anesthesia can be the technique of choice for selected ambulatory surgery procedures, but in spite of its benefits, it has an inherent failure rate even in experienced hands. We examine the efficacy and factors associated with failure of ambulatory regional anesthesia techniques.

Methods: This study included 9,342 blocks performed on 7,160 patients at the Duke University Ambulatory Surgery Center. Blocks were classified as interscalene, supraclavicular, axillary, lumbar plexus, femoral, sciatic, ankle, paravertebral, spinal, and other (frequency less than 100). A block was considered surgical if a single attempt at placing the block resulted in a complete sensory, motor, and sympathetic nerve block. Multiple logistic regression analyses were used to assess the risk-adjusted association between patient characteristics and block failure.

Results: Paravertebral blocks and those considered in the "other" category had significantly higher failure rates ($P < 0.001$), while spinal and lumbar plexus blocks had lower than average rates of failure ($P < 0.001$ and $P = 0.03$, respectively).

In multiple logistic regression analyses excluding paravertebral blocks, body mass index (BMI) scores greater than 25 (P values: BMI 25–29: < 0.001; BMI 30–34: $P < 0.001$; BMI 35: $P < 0.001$) and ASA physical status IV ($P < 0.001$) were significantly associated with higher block failure rates.

Conclusion: High BMI and ASA IV are independent risk factors for block failure in ambulatory surgery patients.

Objectif : *L'anesthésie régionale peut être la technique de choix pour certaines interventions chirurgicales ambulatoires, mais en dépit de ses avantages, elle présente un taux d'échec inhérent même entre des mains expertes. Nous vérifions l'efficacité des techniques d'anesthésie régionale ambulatoire et les facteurs associés à son échec.*

Méthode : *Notre étude comprend 9 342 blocs réalisés sur 7 160 patients au Duke University Ambulatory Surgery Center. Les blocs ont été classifiés comme interscalène, supraclaviculaire, axillaire, du plexus lombaire, fémoral, sciatique, de la cheville, paravertébral, rachidien et autre (d'une fréquence de moins de 100). Un bloc était considéré chirurgical si un seul essai provoquait un blocage nerveux sensitif, moteur et sympathique. Des analyses de régression logistique multifactorielle ont servi à évaluer l'association ajustée au risque entre les caractéristiques du patient et l'échec du bloc.*

Résultats : *Les blocs paravertébraux et ceux de la catégorie «autre» avaient un taux d'échec significativement plus élevé ($P < 0,001$), tandis que les blocs rachidiens et ceux du plexus lombaire avaient un taux d'échec sous la moyenne ($P < 0,001$ et $P = 0,03$, respectivement). Dans les analyses de régression logistique excluant les blocs paravertébraux, les indices de masse corporelle (IMC) de plus de 25 (IMC de 25–29: $P < 0,001$; IMC de 30–34: $P< 0,001$; IMC de 35: $P < 0,001$) et un état physique ASA IV ($P < 0,001$) étaient significativement associés à des taux d'échec de bloc plus élevés.*

Conclusion : *Un IMC élevé et un état physique ASA IV sont des facteurs de risque indépendants d'échec du bloc en chirurgie ambulatoire.*

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REGIONAL anesthesia offers several advantages over general anesthesia, such as decreased postoperative nausea and vomiting,[1] and improved postoperative pain control, particularly when long-acting local anesthetics[2] or continuous peripheral nerve catheters[3] are used. As a result, regional anesthesia is often the technique of choice for selected ambulatory surgery procedures. However, regional anesthesia has an inherent failure rate even in experienced hands. Block failures can delay the surgical schedule, as well as subject patients to repeated block attempts or unanticipated general anesthesia.

Many technical variables have been found to be associated with block failure, such as injection of anesthetics outside of the neurovascular sheath,[4,5] rapid injection speed;[6] and a high threshold for stimulation when using a nerve stimulator technique.[7] The association of other variables and block failure is debated. Regarding brachial plexus blocks, some authors reported better outcomes with increasing injection volumes,[4,8] while others found no association.[7] The experience of the anesthesiologist placing the block has been reported to impact the rate of success by some authors,[8–11] but this finding is controversial.[12] Moreover, obesity and patient non-compliance have been reported as risk factors for block failure.[13]

Despite these technical variables that contribute to failure, limited studies have examined patient characteristics associated with increased block failure. The goal of this study was to analyze a large clinical practice and identify regional anesthesia techniques and patient characteristics most frequently associated with block failure.

Methods

Institutional Review Board approval for this study was waived under Title 45, Part 46.116 (c) and (d) of the Code of Federal Regulations for the Protection of Human Subjects. In this study, 7,160 patients classified as ASA physical status I to IV, aged 13 or older, participated in this prospective case collection. All patients receiving regional anesthesia at the Duke University Ambulatory Surgery Center (ASC) between July 13, 1998 and March 27, 2001 were analyzed. Ambulatory surgery was defined as a hospital stay shorter than 23 hr. Data for each patient were prospectively collected by board-certified anesthesiologists, clinical research nurses, and anesthesia fellows. Data were entered in the Duke University Medical Center Ambulatory Surgery Center Database (ASCDB) using commercially available software. The ASCDB enrolled each surgical case in a database protocol compiling information on socio-demographics and surgical and anesthetic procedures.

Anesthetic techniques were determined by the individual anesthesiologist and performed by attending staff, fellows and residents (clinical anesthesia year two and three). Standard practice at our facility is to offer regional anesthesia options whenever possible. Patients were typically provided sedation with midazolam and fentanyl, being arousable to stimulation (e.g., by calling the patient's name). The standard of care for sedation in our ASC consists of intermittent doses of midazolam up to 5 mg and intermittent doses of fentanyl up to 250 μg. All peripheral nerve blocks were performed using a nerve stimulator technique. The current was less than 0.5 mA for all blocks. The standard mixtures of anesthetic drugs are displayed in the Appendix. All paravertebral blocks were performed using a loss-of-resistance technique. Patients were not excluded for any reason.

Outcomes

The main outcome measure was block failure. Each block performed was classified as "surgical" or "failed." A block was considered surgical if a single attempt at placing the block resulted in a complete sensory, motor, and sympathetic nerve block (surgical anesthesia). Block failure was defined as any non-surgical block and included those that required repeated attempts at placing the block or infiltration of local anesthetic into the surgical site, as well as those that resulted in conversion to general anesthesia. Anesthesiologists were allowed to localize the nerve(s) more than once if the first needle pass did not result in an adequate muscle twitch. If surgical anesthesia was not obtained in patients simultaneously undergoing multiple regional anesthesia procedures, all blocks were defined as non-surgical failed.

Main effects

The primary predictor variable was the block type performed. Blocks were classified as interscalene, continuous interscalene, supraclavicular, axillary, lumbar plexus, continuous lumbar plexus, femoral, sciatic, continuous sciatic, ankle, paravertebral, and spinal. An additional "other blocks" category was created to include blocks that were performed less than 100 times in the study period. These blocks were superficial cervical plexus, continuous supraclavicular, infraclavicular, continuous infraclavicular, continuous axillary, wrist, continuous femoral, saphenous, continuous paravertebral, and continuous epidural.

Confounding variables

To evaluate the risk-adjusted association between patient characteristics and rate of block failure, age, gender, body mass index (BMI), ASA physical status classification, type of surgical service, and block type were included in the statistical models. Age was used as a continuous variable and measured in years. Each patient's BMI (calculated as weight measured in kilograms over squared height measured in metres) was categorized as < 25 kg·m^{-2}, 25 to 29 kg·m^{-2}, 30 to 34 kg·m^{-2}, or > 35 kg·m^{-2}. We used BMI as a categorical rather than a continuous variable since the association between BMI and outcomes was not linear. If we had used BMI as a continuous variable, we would have artificially forced this association to be linear. Thus, choosing ordinal BMI categories represents the more rigorous methodological approach. Surgical services included orthopedic surgery, general surgery, urology, plastic surgery, and gynecology. Furthermore, for risk-adjustment in multivariable analyses, we have categorized the regional anesthesia procedures into four subsets to combine blocks with similar characteristics: 1) centroneuraxial blocks (spinal blocks, continuous epidural blocks); 2) peripheral nerve blocks (superficial cervical plexus, interscalene, supraclavicular, infraclavicular, axillary, wrist, lumbar plexus, femoral, sciatic, saphenous, and ankle); 3) continuous peripheral nerve blocks (continuous interscalene, continuous supraclavicular, continuous infraclavicular, continuous axillary, continuous lumbar plexus, continuous femoral, continuous sciatic); 4) paravertebral blocks (paravertebral, continuous paravertebral).

Statistical analysis

Descriptive analyses were performed using means and standard deviation for continuous variables and frequencies and percentages for categorical variables. Unadjusted comparisons between block failure and individual block types were performed using Chi-squared tests. The risk-adjusted association between individual variables and block failure was evaluated using logistic regression models. Dummy variables for different BMI and ASA categories were used to evaluate the linear trend between these variables and block failure.

Results

The patient population included similar percentages of women (53.2%) and men, with an average age of 48 ± 17 yr. The BMI distribution was 33.6% < 25 kg·m^{-2}, 32.8% 25 to 29 kg·m^{-2}, 17.6% 30 to 34 kg·m^{-2}, and 12.6% > 35 kg·m^{-2}. The distribution of ASA physical status was class I (n = 1,411; 19.7%), class II (n = 3,929; 54.8%), class III (n = 1,568; 21.9%), and class IV (n = 122; 1.7%). Finally, the distribution of surgical service was orthopedic surgery (60.3%), general surgery (29.6%), urology (4.6%), plastic surgery (3.0%), and gynecology (1.4%). Missing values were encountered for gender [n = 78 (1.1%)], BMI [n = 240 (3.3%)], ASA physical status [n = 132 (1.8%)], and surgical service [n = 80 (1.1%)].

There were 9,342 blocks performed on 7,160 patients. Of these 7,160 patients, 5,070 received one block, 2,000 received two blocks (combinations of lumbar plexus/sciatic or femoral/sciatic or brachial plexus/paravertebral blocks), 88 received three blocks (combinations of lumbar plexus/sciatic/saphenous or femoral/sciatic/saphenous or lumbar plexus/sciatic/paravertebral or femoral/sciatic/paravertebral blocks), and two received four blocks (combinations of lumbar plexus/paravertebral/saphenous/sciatic or femoral/paravertebral/saphenous/sciatic blocks). The distribution of blocks was interscalene (12.6%), continuous interscalene (4.3%), supraclavicular (4.7%), axillary (5.4%), lumbar plexus (10.6%), continuous lumbar plexus (2.5%), femoral (6.1%), sciatic (17.1%), continuous sciatic (3.2%), ankle (2.5%), paravertebral (18.6%), and spinal (9.9%). The additional "other" category included 24 superficial cervical plexus, five continuous supraclavicular, 14 infraclavicular, one continuous infraclavicular, 24 continuous axillary, 21 wrist, 11 continuous femoral, 79 saphenous, 15 continuous paravertebral, and 56 continuous epidural blocks.

Unadjusted block failure rate for each patient characteristic is presented in Table I. Age was not significantly associated with block efficacy (P = 0.16). There was a higher unadjusted block failure rate among females (P = 0.003), patients with higher BMI scores (P = 0.002), and higher ASA physical status (P < 0.001). Significant unadjusted differences in block failure rate were also found among different surgical services, with higher failure rates in patients undergoing orthopedic and general surgery procedures (P = 0.02).

Block failure rate did not significantly increase in patients receiving more than one block (block failure rate: one block: 6.3%, two blocks: 10.1%, three blocks: 15.2%, P = 0.12, Chi-squared test).

Block efficacy for specific block techniques is presented in Table II. The average rate of surgical blocks was 89.1%. Two block types had failure rates that were significantly higher than average when compared to all block types, specifically paravertebral blocks (P < 0.001) and those blocks considered in the "other blocks" category (P < 0.001). Compared with the average, block failure rate was significantly lower in spinal blocks (P < 0.001) and lumbar plexus blocks (P = 0.03). All other types of blocks had comparable failure rates. These

TABLE I Unadjusted block failure rate

Patient variable	*Clinical outcome (%)** *Surgical block*	*Failed block*	*Total (%)*	*P value*
Age (yr; mean ± SD)	48.1 ± 16.9	49.0 ± 17.0		$P = 0.16$
Gender			$P = 0.003$	
Male	90.3	9.7	3,274 (45.7)	
Female	88.1	12.0	3,808 (53.2)	
Missing			78 (1.1)	
BMI (kg·m⁻²)				$P = 0.002$
< 25	90.5	9.5	2,405 (33.6)	
25-29	89.4	10.7	2,350 (32.8)	
30-34	88.1	11.9	1,261 (17.6)	
> 35	86.1	13.9	904 (12.6)	
ASA physical status				$P < 0.001$
I	90.3	9.7	1,411 (19.7)	
II	89.9	10.1	3,927 (54.8)	
III	86.7	13.3	1,568 (21.9)	
IV	81.8	18.2	122 (1.7)	
Missing			132 (1.8)	
Surgical service				$P = 0.02$
Orthopedic	88.7	11.3	4,314 (60.3)	
General	88.8	11.2	2,120 (29.6)	
Urology	91.1	8.9	326 (4.6)	
Plastic	95.0	5.1	218 (3.0)	
Gynecology	93.1	6.9	102 (1.4)	
Missing			80 (1.1)	

*Percentages represent frequency of outcome for each patient characteristic. Due to rounding, not all percentages total 100%. BMI = body mass index.

TABLE II Block failure rate by block type

Type of block	*Frequency of outcome (%)** *Surgical block*	*Failed block*	*Total blocks (%)*	*P value*
All blocks	89.1	10.9	9,342 (100%)	
Interscalene	90.6	9.4	1,173 (12.6%)	0.07
Continuous interscalene	89.9	10.1	405 (4.3%)	0.62
Supraclavicular	89.7	10.3	436 (4.7%)	0.71
Axillary	88.9	11.1	505 (5.4%)	0.87
Lumbar plexus	91.2	8.8	986 (10.6%)	0.03
Continuous lumbar plexus	91.9	8.1	235 (2.5%)	0.16
Femoral	88.0	12.0	568 (6.1%)	0.38
Sciatic	90.3	9.7	1,595 (17.1%)	0.10
Continuous sciatic	90.9	9.1	297 (3.2%)	0.32
Ankle	89.6	10.4	231 (2.5%)	0.81
Paravertebral	81.5	18.5	1,737 (18.6%)	< 0.001
Spinal	96.8	3.3	924 (9.9%)	< 0.001
Other	81.4	18.6	250 (2.7%)	< 0.001

*Percentages represent frequency of outcome within specific type of block. Due to rounding, not all percentages total 100%.

included interscalene, continuous interscalene, supraclavicular, axillary, femoral, sciatic, continuous sciatic, and ankle.

Predictive regression models are presented in Table III. The first model including all patients indicates that patients who are female, with higher BMI and a higher ASA class had an increased risk of block failure. Because the association between female gender and block failure was suspected to be related to the high rates of failure associated with paravertebral blocks, a second model excluded patients undergoing paravertebral blocks. In this second model, female gender was no longer associated with block failure below the level of statistical significance. Conversely, higher BMI and

TABLE III Risk-adjusted block failure rate

Patient variable	*Relative risk of block failure (95% confidence interval, P value)* *Model 1**	*Model 2†*
Gender		
Male	Referent	Referent
Female	1.32 (1.07-1.56, $P < 0.001$)	1.10 (0.84-1.39, $P = 0.36$)
BMI (kg·m^{-2})		
< 25	Referent	Referent
25-29	1.45 (1.03-1.64, $P = 0.02$)	1.43 (1.14-1.96, $P < 0.001$)
30-34	1.40 (1.05-1.83, $P < 0.001$)	1.76 (1.34-2.62, $P < 0.001$)
> 35	1.50 (1.21-2.34, $P < 0.001$)	2.06 (1.53-2.98, $P < 0.001$)
ASA physical status		
I	Referent	Referent
II	1.00 (0.79-1.28, $P = 0.73$)	1.01 (0.91-1.45, $P = 0.46$)
III	1.39 (0.99-1.92, $P = 0.10$)	1.46 (0.97-2.21, $P = 0.13$)
IV	2.39 (1.34-4.32, $P < 0.001$)	2.95 (1.14-5.93, $P < 0.001$)
Surgical service		
Orthopedics	2.74 (1.02-7.46, $P = 0.02$)	2.04 (0.64-6.69, $P = 0.46$)
General	2.58 (0.91-7.34, $P = 0.33$)	2.01 (0.72-6.49, $P = 0.53$)
Urology	2.24 (0.77-6.58, $P = 0.63$)	1.77 (0.52-6.45, $P = 0.73$)
Plastic	1.22 (0.42-3.93, $P = 0.26$)	1.21 (0.32-4.91, $P = 0.83$)
Gynecology	Referent	Referent
Block type		
Centroneuraxial blocks	Referent	Referent
Peripheral nerve blocks	1.46 (1.16, 1.83, $P < 0.001$)	2.42 (1.76, 3.35, $P < 0.001$)
Continuous peripheral nerve blocks	1.50 (1.13, 1.98, $P < 0.001$)	2.38 (1.69, 3.35, $P < 0.001$)
Paravertebral blocks	3.56 (2.82, 4.49, $P < 0.001$)	NA

*Model including all patients. †Model excluding patients undergoing paravertebral blocks. Both models are adjusted for age, gender, BMI, ASA physical status classification, type of surgical service, and block type. BMI = body mass index.

ASA class IV remained significantly associated with block failure.

Discussion

This study identifies patient characteristics associated with increased rates of block failure using prospectively collected data from a large patient sample with over 21 regional anesthesia techniques. High BMI and ASA physical status IV represent independent risk factors for block failure. To our knowledge, a previous analysis is unavailable.

Our study found that, regardless of block type, patients with a BMI greater than 25 kg·m^{-2} are more likely than those with lower BMI to experience non-surgical anesthesia (Table III). Additionally, the rate of failed block increased incrementally with BMI. This association of high BMI with block failure seems logical since it is more difficult to identify appropriate landmarks that indicate the position of peripheral nerves in obese patients.[14] The difficulty of performing regional anesthesia in this patient population has been poorly addressed in the literature. While some authors recommend their specific regional anesthesia techniques for obese patients,[15] few have demonstrated that obese patients are more likely to experience block failure. Gatra *et al.*, assessing the efficacy of supraclavicular brachial plexus block, found that block failure was more common among obese and non-cooperative patients.[13] However, the study was limited to only 50 patients and a definition of "obese" is missing. In contrast, Conn *et al.*[12] found no association between block failure and patient height or weight. Likewise, Carles *et al.*[7] found no association between block failure and patient characteristics in a study of 1,468 brachial plexus blocks performed at the humeral canal with a nerve stimulator. The results of these two studies should, however, be examined carefully when considering factors that make a patient more likely to experience a failed block in general. Generalization of both the Conn and Carles studies should be limited as they evaluated one single specific block, while the present study included a wide variety of regional techniques on a very large patient population.

The association between ASA class and block failure is also poorly addressed in the literature. Naja and Lonnqvist[15] recommend using a nerve stimulator for thoracic and lumbar paravertebral blocks in elderly patients and patients with cardiopulmonary disease, but the authors do not discuss ASA class as a predictor of block failure. Several studies[5,8,9] have also found that more experienced anesthesiologists have higher rates of surgical block. Therefore, patients at high risk for block failure, especially those with high ASA class who might benefit most from regional anesthesia, should be cared for by more experienced anesthesiologists.

In addition to the association between block failure and patient characteristics, specific blocks, namely paravertebral blocks and remaining blocks considered in the "other blocks" category, had significantly higher unadjusted block failure rates. This may be related to the different technique utilized to perform the majority of these blocks (e.g., loss-of-resistance technique). In the case of the "other blocks" category, the higher rate of failure could be related to the fact that the category combines several regional anesthesia techniques, such as continuous epidural, continuous paravertebral, continuous supraclavicular and superficial cervical plexus, all of which are performed relatively infrequently.

It should be noted that the dearth of literature addressing patient characteristics associated with block failure might be related to different definitions of "failure." In the present investigation, a block was considered surgical if a single attempt at placing the block resulted in a complete sensory, motor, and sympathetic nerve block. All other blocks were considered failed, including those that required conversion to general anesthesia, a second block attempt, or infiltration of local anesthetic at the surgical site during surgery. Other authors might consider those blocks successful. For example, in a study of lower extremity blocks, Dilger[16] argues that blocks which require infiltration of local anesthetic or even general anesthesia should be considered successful since the block will provide postoperative analgesia.

In spite of significant advances in relation to previous studies, our study has limitations. First, all blocks were performed at a single academic institution and by a relatively small group of anesthesiologists highly trained in advanced regional anesthesia. Thus, the findings of the present investigation might not be reproducible if regional anesthesia was performed by less trained or less experienced anesthesiologists. Other limitations include small sample sizes for particular regional anesthesia techniques, an uneven distribution of patients among ASA physical status and surgical services, and clustering of events in patients undergoing simultaneous multiple regional anesthesia procedures.

Despite the above-mentioned drawbacks, this study also has numerous strengths. First, the sample size is larger than in any previous publication, enabling us to reach conclusions with great confidence. Second, as opposed to most previous studies, a broad variety of regional anesthesia techniques were evaluated, which increases the applicability of our findings. Also, data collection at one large centre enabled us to clearly separate patients factors that influence block failure from other confounders, particularly anesthesia related factors. Third, our analysis is based on a consecutive patient sample, thus minimizing selection bias, and finally, all data were collected prospectively and the dataset is very complete.

In conclusion, the present investigation enabled us to identify a subset of ambulatory surgery patients with increased risk of block failure. Patients who have a BMI greater than 25 $kg \cdot m^{-2}$ or who are classified as ASA IV were more likely to receive "non-surgical" regional anesthesia techniques. Knowing the probability of block failure in this patient population, additional studies are needed to identify the impact of block failure in the ambulatory setting. Unplanned general anesthesia, increase in length of PACU stay, unanticipated hospital admissions, and finally increase in healthcare costs should be evaluated.

APPENDIX Concentrations, volumes and dosages of local anesthetics

Peripheral nerve blocks: ropivacaine 0.5%, mepivacaine 1.5%, or mepivacaine 1% at the discretion of the anesthesiologist performing the block

Paravertebral blocks: ropivacaine 0.5% or 1%
Spinal blocks: lidocaine 5%, bupivacaine 0.75%, ropivacaine 1%, or 0.5%
Epidural blocks: lidocaine 2% or ropivacaine 0.5%
Superficial cervical plexus blocks: 10 mL
Brachial plexus blocks: 30–40 mL of local anesthetic are used for interscalene, supraclavicular, infraclavicular, and axillary blocks
Paravertebral blockade:
Thoracic levels: 5 mL per level
Lumbar levels: 5–7 mL per level
Lumbar plexus blocks: 25–35 mL
Femoral nerve blocks: 25–35 mL
Transsartorial saphenous nerve blocks: 10–15 mL
Sciatic nerve blocks: 20–30 mL
Ankle blocks: 30–40 mL
Spinal blocks: ropivacaine 4–12 mg, lidocaine 25–50 mg, bupivacaine 7.5–15 mg
Epidural blocks (initial injection through catheter): lidocaine 300–400 mg, ropivacaine 100–125 mg

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