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# ANESTHESIOLOGY

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Respirators provide reliable protection from airborne respiratory pathogens. Reusable elastomeric respirators offer potential advantages compared to disposable filtering facepiece respirators. Development of improved elastomeric respirators should be an international public health priority.

## The Evolution of the Anesthesia Patient Safety Movement in America: Lessons Learned and Considerations to Promote Further Improvement in Patient Safety

M. A. Warner, M. E. Warner ..... 963

Ellison C. Pierce, Jr., M.D., and a team of innovative leaders led the creation of novel American Society of Anesthesiologists committees, the founding of the Anesthesia Patient Safety Foundation, and the evolution of the anesthesia patient safety movement.

## Perioperative Medicine

### CLINICAL SCIENCE

◆ ◇ Carbon Footprint of General, Regional, and Combined Anesthesia for Total Knee Replacements	
👁 F. McGain, N. Sheridan, K. Wickramarachchi, S. Yates, B. Chan, S. McAlister .....	976

The carbon footprint in carbon dioxide equivalent emissions associated with general anesthesia (n = 9), spinal anesthesia (n = 10), and combined (general and spinal) anesthesia (n = 10) for total knee replacement surgery in Melbourne, Australia, were similar. Single-use equipment, electricity for the patient air warmer, and pharmaceuticals were major sources of carbon dioxide equivalent emissions across all anesthetics. Sevoflurane was a significant source of the carbon dioxide equivalent emissions of both general anesthesia and combined anesthesia. Washing and sterilizing reusable items contributed substantially to the carbon dioxide equivalent emissions of both spinal and combined anesthesia. Oxygen use was an important contributor to the carbon footprint of spinal anesthesia.

◇ Refers to This Month in ANESTHESIOLOGY

◆ Refers to Editorial

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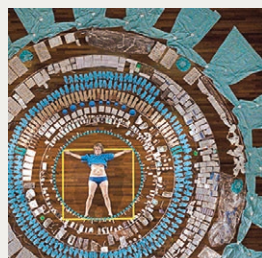
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**ON THE COVER:** Health care itself contributes to climate change. Anesthesia is a “carbon hotspot,” yet few data exist to compare anesthetic choices. In this issue of ANESTHESIOLOGY, McGain *et al.* examined the carbon dioxide equivalent emissions associated with general anesthesia, spinal anesthesia, and combined (general and spinal anesthesia) during a total knee replacement. In an accompanying editorial, Struys and Eckelman discuss how practicing anesthesiologists can lower the environmental footprint of anesthesia. Cover Design: A. Johnson, Vivo Visuals Studio. Cover Image: “This is the waste of one operation... my operation” by Dutch spacial artist Maria Kojck, created with waste generated during her own surgery. Cover Photograph: Eva Glasbeck, published with permission from the artist.

- McGain *et al.*: Carbon Footprint of General, Regional, and Combined Anesthesia for Total Knee Replacements, p. 976
- Struys and Eckelman: Environmental Footprint of Anesthesia: More than Inhaled Anesthetics! p. 937

# ◆ Spinal Anesthesia with Targeted Sedation based on Bispectral Index Values Compared with General Anesthesia with Masked Bispectral Index Values to Reduce Delirium: The SHARP Randomized Controlled Trial

C. H. Brown IV, C. Edwards II, C. Lin, E. L. Jones, L. R. Yanek, M. Esmaili, Y. Gorashi, R. Skelton, D. Kaganov, R. Curto, N. L. Lessing, S. Cha, E. Colantuoni, K. Neufeld, F. Sieber, C. L. Dean, C. W. Hogue.....992

This prospective single-center trial randomized patients undergoing spine surgery to spinal anesthesia with targeted sedation to Bispectral Index greater than 60 to 70 versus general anesthesia without Bispectral Index guidance. There was no difference in the incidence of postoperative delirium between randomized groups in the trial. Future studies are needed to determine whether these findings can be replicated at other centers and whether the results differ by cognitive status. *SUPPLEMENTAL DIGITAL CONTENT IS AVAILABLE IN THE TEXT*

# ◆ Pressure Support versus Spontaneous Ventilation during Anesthetic Emergence—Effect on Postoperative Atelectasis: A Randomized Controlled Trial

H. Jeong, P. Tanatporn, H. J. Ahn, M. Yang, J. A. Kim, H. Yeo, W. Kim.....1004

A randomized trial in patients undergoing laparoscopic colectomy or robot-assisted prostatectomy compared pressure support ventilation to spontaneous ventilation with intermittent manual assistance during anesthetic emergence. The outcome was atelectasis in the postanesthesia recovery unit, using lung ultrasound. The incidence of atelectasis was significantly lower and the  $P_{aO_2}$  was significantly higher with pressure support ventilation; however, in the 48-h postoperative observation period, the incidence of oxygen saturation measured by pulse oximetry less than 92% was not different between groups. *SUPPLEMENTAL DIGITAL CONTENT IS AVAILABLE IN THE TEXT*

# ◆ Preoperative Opioid Utilization Patterns and Postoperative Opioid Utilization: A Retrospective Cohort Study

C. A. Rishel, M. S. Angst, E. C. Sun.....1015

In a national claims database of 57,000 chronic opioid users undergoing common surgical procedures, 41, 22, and 37%, respectively, had stable, decreasing, or increasing preoperative opioid utilization (more than 20% change). After adjustment for potential confounders, 96, 89, and 94% of patients with stable, decreasing, or increasing preoperative opioid use utilized opioids (prescriptions filled) between postoperative days 91 and 365. All three groups had similar average daily oral morphine milligram equivalent utilization. Changes in preoperative opioid utilization were not associated with clinically significant differences in postoperative opioid utilization. *SUPPLEMENTAL DIGITAL CONTENT IS AVAILABLE IN THE TEXT*

## BASIC SCIENCE

# Arterial and Mixed Venous Kinetics of Desflurane and Sevoflurane, Administered Simultaneously, at Three Different Global Ventilation to Perfusion Ratios in Piglets with Normal Lungs

M. Kretzschmar, J. E. Baumgardner, A. Kozian, T. Hachenberg, T. Schilling, G. Hedenstierna, A. Larsson .....1027

The washin and washout kinetics of simultaneously administered desflurane and sevoflurane were assessed in seven piglets by measuring  $P_{mv}$  and  $P_{art}$  during uptake and elimination under normal, low, and high ventilation/perfusion ratio ( $\dot{V}_A/\dot{Q}$ ) conditions. Faster arterial kinetics for desflurane were generally maintained for both washin and washout under all  $\dot{V}_A/\dot{Q}$  conditions. The low  $\dot{V}_A/\dot{Q}$  condition decreased the differences in scaled  $P_{art}$  between 0 and 5 min; the high  $\dot{V}_A/\dot{Q}$  condition increased these differences from the low  $\dot{V}_A/\dot{Q}$  value to a value approaching or exceeding the value for normal  $\dot{V}_A/\dot{Q}$ . Mixed venous kinetics were slower than arterial kinetics for washin and washout and were less influenced by  $\dot{V}_A/\dot{Q}$ .

# Effect of Global Ventilation to Perfusion Ratio, for Normal Lungs, on Desflurane and Sevoflurane Elimination Kinetics

J. E. Baumgardner, M. Kretzschmar, A. Kozian, T. Hachenberg, T. Schilling, A. Larsson, G. Hedenstierna .....1042

A mathematical model of inhaled anesthetic elimination was developed in a *post hoc* analysis of anesthetic partial pressures measured in mixed venous and arterial blood samples after simultaneous administration of desflurane and sevoflurane to seven piglets under normal, low, and high ventilation/perfusion ratio conditions. After a brief and rapid decline in alveolar anesthetic partial pressure, the fractional clearance of anesthetic became constant, and incomplete clearance from the lungs slowed tissue washout. Slowing of tissue elimination by incomplete lung clearance became more pronounced at low ventilation/perfusion ratios, and was predicted to become more pronounced as blood/gas solubility increases.

# Intubation Biomechanics: Clinical Implications of Computational Modeling of Intervertebral Motion and Spinal Cord Strain during Tracheal Intubation in an Intact Cervical Spine

B. C. Gadamski, B. J. Hindman, M. I. Page, F. Dexter, C. M. Puttlitz .....1055

Based on simulation of an adult cervical spine, pathologic motion does not occur even with intubation force up to twice that commonly encountered during routine tracheal intubation. However, in patients who have increased susceptibility to strain-related cord injury, potentially injurious cord strain may occur during routine tracheal intubation conditions. *SUPPLEMENTAL DIGITAL CONTENT IS AVAILABLE IN THE TEXT*

## Critical Care Medicine

### CLINICAL SCIENCE

#### Respiratory Drive in Patients with Sepsis and Septic Shock: Modulation by High-flow Nasal Cannula

T. Mauri, E. Spinelli, B. Pavlovsky, D. L. Grieco, I. Ottaviani, M. C. Basile, F. D. Corte, G. Pintaudi, E. Garofalo, A. Rundo, C. A. Volta, A. Pesenti, S. Spadaro .....1066

Respiratory drive and effort and dynamic lung compliance were evaluated in 25 nonintubated patients with extrapulmonary sepsis or septic shock using arterial blood gases, esophageal pressure monitoring, and electrical impedance tomography at baseline with low-flow nasal oxygen therapy, during high-flow nasal cannula support and again with low-flow nasal oxygen therapy. Patient comfort was evaluated using a 10-point visual analog scale at each step. High-flow nasal oxygen therapy significantly reduced elevated respiratory drive and effort. There was no correlation between patient perceived comfort and measures of drive and effort. The impact of the findings from this physiologic study on patient outcome remain to be determined. *SUPPLEMENTAL DIGITAL CONTENT IS AVAILABLE IN THE TEXT*

#### Treatments Associated with Lower Mortality among Critically Ill COVID-19 Patients: A Retrospective Cohort Study

X. Zhao, C. Gao, F. Dai, M. M. Treggiari, R. Deshpande, L. Meng ....1076

In a retrospective cohort consisting of 2,070 critically ill COVID-19 patients treated in six hospitals, multivariable regression analysis showed lower in-hospital mortality associated with apixaban, aspirin, or enoxaparin treatment. Propensity score-matching analyses demonstrated lower mortality for patients receiving apixaban (27% [96 of 360] vs. 37% [133 of 360]), aspirin (26% [121 of 473] vs. 30% [140 of 473]), or enoxaparin (25% [87 of 347] vs. 34% [117 of 347]) compared to matched controls. *SUPPLEMENTAL DIGITAL CONTENT IS AVAILABLE IN THE TEXT*

## Pain Medicine

### CLINICAL SCIENCE

#### Preoperative Paravertebral Block and Chronic Pain after Breast Cancer Surgery: A Double-blind Randomized Trial

A. Albi-Feldzer, S. Dureau, A. Ghimouz, J. Raft, J.-L. Soubirou, G. Gayraud, C. Jayr .....1091

More than 350 study participants undergoing mastectomy were randomized to either paravertebral blocks with ropivacaine or saline injections. Both groups received multimodal analgesia. Although paravertebral block using ropivacaine had a small analgesic effect in the immediate postoperative period, no differences in pain 3, 6, and 12 months after surgery were detected.

#### Postoperative Pain and Age: A Retrospective Cohort Association Study

J. F. M. van Dijk, R. Zaslansky, R. L. M. van Boekel, J. M. Cheuk-Alam, S. J. Baart, F. J. P. M. Huygen, M. Rijdsdijk .....1104

Data from the PAIN OUT registry involving more than 11,000 patients undergoing spinal surgery, joint replacement, and laparoscopic cholecystectomy were used in a retrospective cohort analysis. Pain reported postoperative day 1 declined slightly with age. Severe postoperative pain was prevalent regardless of age or surgical type.

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### CLINICAL FOCUS REVIEW

#### Prevention of Healthcare-associated Infections in Intensive Care Unit Patients

M. Mazzeffi, S. Galvagno, C. Rock .....1122

Healthcare-associated infections contribute to morbidity, mortality, and increased cost in intensive care unit patients. Understanding evidence-based prevention strategies can help to optimize patient outcomes.

### REVIEW ARTICLE

#### Sleep, Pain, and Cognition: Modifiable Targets for Optimal Perioperative Brain Health

B. P. O'Gara, L. Gao, E. R. Marcantonio, B. Subramaniam .....1132

Multicomponent interventions are effective in preventing postoperative delirium, and work is ongoing to determine whether they can be effective in preventing other postoperative neurocognitive disorders. Interventions optimizing sleep, pain, and cognition are essential components for clinicians to include in strategies to maximize the recovery of body and mind of vulnerable patients.

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