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Economics of Anesthetic Agents

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Economics of Anesthetic Agents

• Reducing drug wastage is simplest
• Changing practice relies on individual feedback and appropriate case adjustment
• Choice of agent influences anesthetic times
• Translation of time into $ is sensitive to the percentage of costs that are fixed
• Predictions require simulation analysis
  – Examples from ICU, PACU, and OR
  – Exceptions are changes in type of anesthesia
Financial Disclosure

• I am employed by the University of Iowa, in part, to consult and analyze data for hospitals, anesthesia groups, and companies

• Department of Anesthesia bills for my time, and the income is used to fund our research
  – I receive no funds personally other than my salary and allowable expense reimbursements from the University of Iowa, and have tenure with no incentive program
  – I own no healthcare stocks (other than indirectly through mutual funds)
Financial Disclosure

- Much of the work presented in this lecture has been funded by consulting done by the University of Iowa (i.e., me) for companies (partial list)
  - Aspect Medical Systems
  - Organon
  - Baxter
  - Merck
Economics of Anesthetic Agents

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Reducing Fresh Gas Flow Rates Is Simple Conceptually

• Providing feedback to anesthetists of their overall mean fresh gas flows reduced consumption by 15% and 26%

Lubarsky DA et al. Anesthesiology 1997
Body SC et al. Anesthesiology 1999
Providing feedback to anesthetists of their overall mean fresh gas flows reduced consumption by 15% and 26%.

Most of the benefit is from small reductions in flows for the many cases with rates $< 3$ liters per minute, not from changing the behavior of few providers with very big flows.

Lubarsky DA et al. Anesthesiology 1997
Body SC et al. Anesthesiology 1999
Dexter F et al. Anaesth Intensive Care 2011
Reducing Fresh Gas Flow Rates Is Simple Conceptually

- Providing feedback to anesthetists of their overall mean fresh gas flows reduced consumption by 15% and 26%
  - Most of the benefit is from small reductions in flows for the many cases with rates < 3 liters per minute, not from changing the behavior of few providers with very big flows
  - Can use automated, real time recommendations

Lubarsky DA et al. Anesthesiology 1997
Body SC et al. Anesthesiology 1999
Dexter F et al. Anaesth Intensive Care 2011
Reducing Fresh Gas Flow Rates Is Simple Conceptually

- Consider education on importance of induction, because median 27% of total fresh gas used during the initial high-flow phase.

Kennedy RR et al. Anaesthesia 2019
Reducing Opened and Unused Drugs Is Simple Conceptually

• FY96, $9.60 per case (acquisition costs)
  – 28% of total anesthesia drug costs
• FY98, $13.27 per case
  – 26% of total anesthesia drug costs
• FY00, $10.86 per case
• FY13, $ 3.90 per case

Dexter F et al. Anesthesiology 1998
Gillerman RG, Browning RA. Anesth Analg 2000
Weinger MB. J Clin Anesth 2001
Reducing Opened and Unused Drugs Is Simple Conceptually

- I recommend starting with this change
  - Easy to quantify
  - Easy to understand that wasting drugs is counter-productive
  - No adverse consequence for patients
  - Reducing fresh gas flows not only reduces wastage of volatile anesthetics, but may also help the environment
Reducing Opened and Unused Drugs Is Simple Conceptually

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  - Easy to quantify
  - Easy to understand that wasting drugs is counter-productive
  - No adverse consequence for patients
  - Reducing fresh gas flows not only reduces wastage of volatile anesthetics, but may also help the environment

➢ Still, though, will need analysis and software
Example 1 of Reducing Wastage

• Costs and benefits of program to reduce wastage of intravenous drugs using instead commercially prepared syringes is simple to measure
  – Cost of commercial syringe
  – Cost of standard syringe
  – Reduced wastage

Barbariol F et al. Anesth Analg 2021
Example 1 of Reducing Wastage

• Which of the following provides the cheapest total cost?
  – Ephedrine 30 mg drawn by anesthesiologist
  – Ephedrine 30 mg obtained commercially
  – No way to know without measuring wastage across multiple hospitals and doing the inventory-control mathematics
Example 1 of Reducing Wastage

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  – Ephedrine 30 mg obtained commercially
  – No way to know without measuring wastage across multiple hospitals and doing the inventory-control mathematics

➢ Let the pharmacy decision-analyst with software figure it out
Example 2 of Reducing Wastage

- Which of the following provides the cheapest total cost for maintenance?
  - Desflurane with 4.0 liter fresh gas flow
  - Desflurane with 3.0 liter fresh gas flow
  - Desflurane with 2.0 liter fresh gas flow
  - Desflurane with 1.0 liter fresh gas flow
Example 2 of Reducing Wastage

• Which of the following provides the cheapest total cost for maintenance?
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  - Desflurane with 3.0 liter fresh gas flow
  - Desflurane with 2.0 liter fresh gas flow
  - Desflurane with 1.0 liter fresh gas flow

- It really is that simple conceptually (plus newer anesthesia machines have automated control of low-flow delivery)

Tay S et al. Anaesth Inten Care 2013
Economics of Anesthetic Agents

• Reducing drug wastage is simplest

➢ Changing practice relies on individual feedback and appropriate case adjustment

• Choice of agent influences anesthetic times

• Translation of time into $ is sensitive to the percentage of costs that are fixed

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  – Examples from ICU, PACU, and OR
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Education Alone Does Not Influence Anesthesia Providers

- Poor cost consciousness of anesthesia providers, particularly for expensive drugs

Education Alone Does Not Influence Anesthesia Providers

- Poor cost consciousness of anesthesia providers, particularly for expensive drugs
  - Price stickers and education significantly enhance cost-consciousness

Snyder-Ramos SA et al. Der Anaesthesist 2003
Education Alone Does Not Influence Anesthesia Providers

- Poor cost consciousness of anesthesia providers, particularly for expensive drugs
- Price stickers and education significantly enhance cost-consciousness
  - However, that does not change drug usage for equivalent drugs

Snyder-Ramos SA et al. Der Anaesthesist 2003
Provider-Specific Feedback Needs to be Patient Specific

- Determining appropriate patients for anti-emetics relies on logistic regression
  - Female gender
  - Prior history of PONV or motion sickness
  - Nonsmoking
  - Postoperative opioids

Apfel CC et al. Anesthesiology 1999
Provider-Specific Feedback
Needs to be Timely
Provider-Specific Feedback Needs to be **Timely**

- Risk-adjusted outcome feedback increases percentage of patients receiving protocol-driven nausea/vomiting therapy
  - Every 1 month: absolute increase 29%
  - Every 3 months: absolute increase 12%

Cohen MM et al. Anesthesiology 1996
Provider-Specific Feedback Needs to be **Timely**

- Risk-adjusted outcome feedback increases percentage of outpatients bypassing the phase I post-anesthesia care unit
  - Every **week**: absolute increase 43%
  - Every **day**: absolute increase 83%

Apfelbaum JL et al. Anesthesiology 2002
Provider-Specific Feedback Needs to be Timely

• Provide immediate feedback when using drug that is not part of protocol for the patient
  – Reduced intravenous anesthetic costs 51%
  – Reduced neuromuscular blocker costs 47%

Lubarsky DA et al. Anesthesiology 1997
Freund PR et al. Anesthesiology 1997
Provider-Specific Feedback Needs to be Timely

• Provide immediate feedback when using drug that is not part of protocol for the patient
  – Reduced intravenous anesthetic costs 51%
  – Reduced neuromuscular blocker costs 47%

➢ Can provide using either drug dispensing system or using anesthesia information management system (AIMS)

Epstein RH et al. Anesth Analg 2016 (× 2)
Provider-Specific Feedback Needs to be Timely

• Provide immediate feedback when using drug that is not part of protocol for the patient
  – Reduced intravenous anesthetic costs 51%
  – Reduced neuromuscular blocker costs 47%

• Can provide using either drug dispensing system or using anesthesia information management system (AIMS)

➢ Advantages to delivering by e-mail include appropriate lack of regulatory requirements and ease of maintenance

Provider-Specific Feedback on Costs Need to be Adjusted

• American Society of Anesthesiologists’ Relative Value Guide (ASA RVG) were known for every case that was billed (i.e., for every case)
  – Case duration: use ASA RVG time units
  – Type of procedure: use ASA RVG base units

• Explained 54% of variation in costs
  – Corrected for variation in anesthetic drug costs among sub-specialties

Dexter F et al. Anesthesiology 1998
Provider-Specific Feedback Can Also Include Time

• Monitor the 15% of AIMS’ cases with prolonged extubation times (≥ 15 min)
  – Direct cost of the time focus of rest of talk
  – Intangible cost of the time shown by these cases’ having mean 4.9 min longer times from out of OR to start of surgery of surgeon’s next case (95% CI 2.7 min to 7.1 min, P < 0.0001)

Dexter F et al. Anesth Analg 2010
Dexter F, Hindman BJ. Anesth Analg 2024
Provider-Specific Feedback Can Also Include Time

• Incidence of prolonged extubation times is composite end point for reductions in both:
  – Average (mean)
  – Variability (standard deviation)

Dexter F et al. Anesth Analg 2010
Dexter F, Hindman BJ. Anesth Analg 2024
Provider-Specific Feedback Can Also Include Time

- Incidence of prolonged extubation times is composite end point for reductions in both:
  - Average (mean)
  - Variability (standard deviation)

  Mostly variability
  - Prolonged 39% University of Iowa (N=785) vs. 6% Kameda Medical Center (N=685)
  - Means 10 vs. 9 minutes (P = 0.68)
  - Standard deviations 40 vs. 4 min (P < 0.0001)

Sugiyama D et al. Anesth Analg 2021
Provider-Specific Feedback Can Also Include Time

- Can reduce incidence prolonged extubation
- Examples using desflurane
  - Reduces incidence 65% versus sevoflurane
  - Reduces incidence 78% versus isoflurane

Dexter F et al. Anesth Analg 2010
Agoliati A et al. Anesth Analg 2010
Dexter F, Hindman BJ. J Clin Anesth 2023
Provider-Specific Feedback Can Also Include Time

- Ambulatory surgery center OR
  - 1000 general anesthetics per year $\times$ 5% rate of prolonged extubation times
    $= 1$ event per week
  - 75% reduction results in 1 event per month

- Hospital OR
  - 750 general anesthetics per year $\times$ 20% rate of prolonged extubation times
    $= 3$ events per week
  - 95% reduction results in < 1 per month
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Matters That Drugs Influence Anesthetic Times

Get your anesthesia performance on the fast track.

Suprane® desflurane USP
The Fast Track Anesthetic®
Matters That Drugs Influence Anesthetic Times

Minutes from closure of incision to extubation

Matters That Drugs Influence Anesthetic Times

Minutes from closure of incision to extubation

Matters That Drugs Influence Anesthetic Times

- Prolonged extubations cause increase in times from end of surgery to OR exit?
  - No, not significantly, other concurrent processes influence time of OR exit
  - Yes, significantly, but just 1 to 2 minutes
  - Yes, significantly, on average \( \approx \) 5 minutes
  - Yes, significantly, on average \( > \) 10 minutes

Dexter F, Epstein RH. Anesth Analg 2013
Dexter F, Hindman BJ. Anesth Analg 2024
Matters That Drugs Influence Anesthetic Times

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  – Yes, significantly, on average \( \approx 5 \) minutes
  – Yes, significantly, on average > 10 minutes

Dexter F, Epstein RH. Anesth Analg 2013
Dexter F, Hindman BJ. Anesth Analg 2024
Matters That Drugs Influence Anesthetic Times

• Prolonged extubations cause increase in times from end of surgery to OR exit
  – Mean $13.0 \pm 0.1$ minutes (SE) when stratified by duration of surgery and prone or not
  • Longer than 10 minutes, $P < 0.0001$
  – Absolute % increase in risk of case taking longer than scheduled is $11.0\% \pm 0.5\%

Dexter F, Epstein RH. Anesth Analg 2013
Matters That Drugs Influence Anesthetic Times

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➤ Monitoring prolonged extubations is valid

Bayman EO et al. Anesthesiology 2016
Matters That Drugs Influence Anesthetic Times

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  - Longer than 10 minutes, $P < 0.0001$
  - Absolute % increase in risk of case taking longer than scheduled is $11.0\% \pm 0.5\%$

- Monitoring prolonged extubations is valid
  - Unlike time from end of surgery to OR exit, since increased by factors unrelated to anesthetic such as the PACU being full
Matters That Drugs Influence Anesthetic Times

- Drugs with a higher acquisition costs can truly be cheaper by reducing time

Tyler DC, Orr RJ. Am J Anesthesiol 1999
Matters That Drugs Influence Anesthetic Times

- Drugs with a higher acquisition costs can truly be cheaper by reducing time
  - Anesthesiologists give poor rating to recovery from anesthesia when prolonged extubation

Tyler DC, Orr RJ. Am J Anesthesiol 1999
Apfelbaum JL et al. Anesth Analg 1993
Matters That Drugs Influence Anesthetic Times

- Drugs with a higher acquisition costs can truly be cheaper by reducing time
- Anesthesiologists give poor rating to recovery from anesthesia when prolonged extubation
  - Anesthesiologists perceive strong production pressure to work quickly

Tyler DC, Orr RJ. Am J Anesthesiol 1999
Apfelbaum JL et al. Anesth Analg 1993
Gaba DM et al. Anesthesiology 1994
Chai JX, Chong SY. Singapore Med J 2018
Matters That Drugs Influence Anesthetic Times

- Drugs with a higher acquisition costs can truly be cheaper by reducing time
- Anesthesiologists give poor rating to recovery from anesthesia when prolonged extubation
- Anesthesiologists perceive strong production pressure to work quickly
  - Cognitive bias (i.e., immutable to education)

Tyler DC, Orr RJ. Am J Anesthesiol 1999
Apfelbaum JL et al. Anesth Analg 1993
Gaba DM et al. Anesthesiology 1994
Chai JX, Chong SY. Singapore Med J 2018
Matters That Drugs Influence Anesthetic Times

- Surgeons scored importance of 25 attributes of anesthesiologists, using scale from 0 “no importance” to 4 “a factor that would make me switch groups/hospitals”
- For example, as expected, mean score 4.0 for “ability to calmly manage a crisis.”

Matters That Drugs Influence Anesthetic Times

- Surgeons scored importance of 25 attributes of anesthesiologists, using scale from 0 “no importance” to 4 “a factor that would make me switch groups/hospitals”
- For example, as expected, mean score 4.0 for “ability to calmly manage a crisis.”
  - Mean score 3.9 for “patient quick to awaken.”

Measuring Reductions in Time is Straight-Forward

- Results well summarized by meta-analyses
- Example of mean time to extubation
  - Desflurane 25% quicker than sevoflurane
  - 95% confidence interval 17% to 32%
  - Typical corresponding value is 2.5 min

Dexter F et al. Anesth Analg 2010
Small Time Savings per Case
Do Not Simply Add Up

• A hospital estimates its variable costs of OR time to be $20 per minute
  – From cost accounting system
• Desflurane reduces time to following commands by an average of 2.5 minutes
• Savings = $50 per case
  – $50 = $20 per min × 2.5 min per case

Dexter F et al. Anesthesiology 2002
Small Time Savings per Case
Do Not Simply Add Up

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  – From cost accounting system

• Desflurane reduces time to following commands by an average of 2.5 minutes

• Savings = $50 per case
  – $50 = $20 per min × 2.5 min per case

➢ Absurd! Use of desflurane did not save $50
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• Predictions require simulation analysis
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Operating Room Labor is a Step Cost

- Cost accounting system models the variable cost of:
  OR time ≅ (cost of the patient care labor) ÷ (direct patient care time during one quarter)
Operating Room Labor is a Step Cost

• Cost accounting system models the variable cost of:
OR time $\cong \frac{\text{(cost of the patient care labor)}}{\text{(direct patient care time during one quarter)}}$

➢ Assumption is reasonable for an OR allocation analysis that may result in closing an OR

Macario A, Dexter F. AORN J 2000
Operating Room Labor is a Step Cost

- Cost accounting system models the variable cost of:
  OR time ≈ (cost of the patient care labor) ÷ (direct patient care time during one quarter)

- Assumption is reasonable for an OR allocation analysis that may result in closing an OR

- Assumption is not reasonable when considering impact of an anesthetic agent
Operating Room Labor is a Step Cost

- **Fixed costs**
  - Do not change relative to volume of activity
  - Capital equipment and snow removal

- **Variable costs**
  - Change relative to volume of activity
  - Vials of propofol

- **Step costs**
  - Staffing is fixed over narrow ranges of volume of activity, but beyond that must increase
Operating Room Labor is a Step Cost

- Cost accounting system assumes that staff time is a variable cost
Operating Room Labor is a Step Cost

- Cost accounting system assumes that staff time is a variable cost
  - If close an OR, then will have fewer full-time staff, and so the assumption is reasonable over a time course of several months
Operating Room Labor is a Step Cost

- Cost accounting system assumes that staff time is a variable cost.
- If close an OR, then will have fewer full-time staff, and so the assumption is reasonable over a time course of several months.
- If one anesthesiologist decides today to do something different and reduces OR time, then assumption may not be appropriate.
Example – Change in Practice Today by One Anesthesiologist

- 20 anesthesiologist MD group practices at a hospital’s main OR & ambulatory surgery center
- Every Monday, ORs start 1-hr late for nursing training and the anesthesia group’s meeting
- This Monday, hospital manager provides the anesthesiologists with data showing need to reduce drug costs, PACU costs, and OR costs
- Anesthesia group agrees to set up a committee to collaborate with hospital on future changes
Example – Change in Practice Today by One Anesthesiologist

- One of the anesthesiologists, though, wants to affect change immediately.
- She is doing five short cases today.
- To reduce drug costs, she draws up drugs into small syringes, and reduces wastage.
- To reduce PACU costs, she uses BiS and runs a patient light, bypassing phase I PACU.
- To reduce OR costs, she administers a spinal instead of an epidural anesthetic, cutting OR time by around 12 minutes.
Example – Change in Practice Today by One Anesthesiologist

• For which interventions did she really cut costs?
  – To reduce drug costs, she draws up drugs into small syringes, and reduces wastage
  – To reduce PACU costs, she uses BiS and runs a patient light, bypassing phase I PACU
  – To reduce OR costs, she administers a spinal instead of an epidural anesthetic, cutting OR time by around 12 minutes
Example – Change in Practice Today by One Anesthesiologist

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Long-Term Change in Practice by Many Anesthesiologists

• Which interventions really do cut costs?
  – To reduce drug costs, she draws up drugs into small syringes, and reduces wastage
  – To reduce PACU costs, she uses BiS and runs a patient light, bypassing phase I PACU
  – To reduce OR costs, she administers a spinal instead of an epidural anesthetic, cutting OR time by around 12 minutes
  – All 3 of them
Long-Term Change in Practice by Many Anesthesiologists

• Which interventions really do cut costs?

➢ To reduce drug costs, they draw up drugs into small syringes, and reduce wastage
➢ To reduce PACU costs, they use BiS and run their patients light, bypassing phase I PACU
➢ To reduce OR costs, they administer spinals instead of epidural anesthetics, cutting OR times by around 12 minutes
➢ All 3 of them
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➤ Predictions require simulation analysis
  - Examples from ICU, PACU, and OR
  - Exceptions are changes in type of anesthesia
Example 1 of Cardiac Surgery Scenario

- Dr. Jones is a cardiac anesthesiologist
- Off-pump CPB case with extubation in OR
  - Remifentanil anesthetic
- Patient leaves ICU early that evening
- Have ICU nursing costs been reduced?
  - Yes, because every hour of ICU time costs hundreds of dollars
  - No, generally not, because ICU nurses are scheduled a month or so ahead of time
Example 1 of Cardiac Surgery Scenario

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  – Yes, because every hour of ICU time costs hundreds of dollars
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Example 2 of Cardiac Surgery Scenario

• All cardiac anesthesiologists at the hospital
• After off-pump CPB, 90% of patients are extubated in the OR after surgery
• All patients leave ICU in 6 hours
• ICU nursing costs may be reduced
  – Depends on characteristics of the ICU

Straka Z Ann Thorac Surg 2002
Purpose of the Simulation (Economic) Analysis

• Determine whether a reduction in staffing costs can likely be achieved at specific facility
• Facility specific answer depends on ...
  – Whether costs fixed, varies among facilities
• Reduction in costs if they are not fixed
  Not (mean minutes saved) ×
  (total costs) / (total facility minutes)
  – Cost of drug (or device) at the facility

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    - Exceptions are changes in type of anesthesia
Early Tracheal Extubation of Cardiac Surgery Patients

- Early tracheal extubation, achieved with propofol, reduced mean time to extubation from 19 hours to 4 hours, resulting in a reduction in mean ICU LOS of 5.1 hour

- Mean reduction in costs of part-time ICU nurses was $1,012 per patient

Cheng DCH et al. Anesthesiology 1996
Early Tracheal Extubation of Cardiac Surgery Patients

• Early tracheal extubation, achieved with propofol, reduced mean time to extubation from 19 hours to 4 hours, resulting in a reduction in mean ICU LOS of 5.1 hour

• Mean reduction in costs of part-time ICU nurses was $1,012 per patient
Sensitivity of Early Extubation Results to ICU Characteristics

- Cost reduction sensitive to patient flow from scheduling to OR to ICU to hospital ward to long-term care and/or home
  - Specifically, reduction in ICU nursing costs sensitive to number of elective CABG cases performed each year at the hospital and the method of compensating ICU nurses

Sensitivity of Early Extubation Results to ICU Characteristics

- 830 per year ≈ 3-4 elective CABG per day
  - 5 hr reduction in ICU time reliably represents 1 less ICU nurse each day
  - Savings are particularly reasonable, because many part-time nurses
Sensitivity of Early Extubation Results to ICU Characteristics

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- Median elective CABG per day at US hospitals
Sensitivity of Early Extubation Results to ICU Characteristics

- 830 per year \( \approx 3-4 \) elective CABG per day
  - 5 hr reduction in ICU time reliably represents 1 less ICU nurse each day
  - Savings are particularly reasonable, because many part-time nurses
- Median elective CABG per day at US hospitals
  - 1 per day with few part-time ICU nurses
Sensitivity of Early Extubation Results to ICU Characteristics

• 830 per year ≈ 3-4 elective CABG per day
  – 5 hr reduction in ICU time reliably represents 1 less ICU nurse each day
  – Savings are particularly reasonable, because many part-time nurses

• Median elective CABG per day at US hospitals
  – 1 per day with few part-time ICU nurses

➢ Reducing ICU time for 0-1 patients per day for 5 hours unlikely to reduce costs
Two Broad Messages From That ICU Example

- Reductions in time from changing anesthetic drugs *can*, not do, reduce costs
- There needs to be, on that day of the week, a consistently large number of patients who receive the intervention
  - When staff provide care to many patients, only some of whom receive an intervention, the intervention is less likely to reduce costs
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Examples from ICU, PACU, and OR
- Exceptions are changes in type of anesthesia
Methodologies to Simulate Effect of Drugs on PACU Costs

• Dexter F, Tinker JH. Analysis of strategies to decrease post anesthesia care unit costs. Anesthesiology 1995

• Dexter F et al. Computer simulation to determine how rapid anesthetic recovery protocols to decrease the time for emergence or increase the phase I post anesthesia care unit bypass rate affect staffing of an ambulatory surgery center. Anesth Analg 1999

• Dexter F et al. Statistical analysis by Monte-Carlo simulation of the impact of administrative and medical delays in discharge from the post-anesthesia care unit on total patient care hours. Anesth Analg 2001
Important Point is Simply that the Methodologies Exist

• Result, of this type of science, is ...
  – Not an answer to the question: “Does X drug reduce costs”
  – Development and validation of methods to be used with each facility’s own data

• Second of the papers includes Tables that are sufficient for a facility to screen an intervention to decide whether an analysis of its own data is worthwhile
Methodologies to Simulate Effect of Drugs on PACU Costs

- Future slides will focus on some broad, bottom-line, principles from the simulations.
Impact of Nausea and Vomiting

- Observations from the University of Iowa’s Ambulatory Surgery Center in 1993
  - 69% of patients received general anesthesia
  - 8% of patients having general anesthesia suffered nausea and vomiting in the PACU
  - Among patients undergoing general anesthesia, nausea or vomiting increased the mean length of stay by 63%

Dexter F, Tinker JH. Anesthesiology 1995
Impact of Nausea and Vomiting

- Can use these numbers to estimate the decrease in total length of stay that is achievable by reducing nausea and vomiting
  - 69% general
  - 8% of general patients with N & V
  - If N & V, 63% increase in PACU LOS
Impact of Nausea and Vomiting

- Simple estimation
  - Staffing impact = (Incidence) × (Impact)
  - Eliminating nausea and vomiting would decrease total length of stay by 3.4%

3.4% = (69% receiving general × 8% of those receiving general having nausea and/or vomiting) × (63% prolongation of length of stay)
An argument in favor of the aggressive prophylactic treatment of nausea and vomiting is that patients with nausea and vomiting have long PACU stays.

However, ...
Impact of Nausea and Vomiting

• An argument in favor of the aggressive prophylactic treatment of nausea and vomiting is that patients with nausea and vomiting have long PACU stays

➢ PACU patients tend to be in one big room
Impact of Nausea and Vomiting

• An argument in favor of the aggressive prophylactic treatment of nausea and vomiting is that patients with nausea and vomiting have long PACU stays

➢ PACU patients tend to be in one big room
  – Even if there is a subgroup of patients with a high incidence of nausea and vomiting, staffing impact is based on incidence and impact of all patients
Impact of Eliminating Adverse Events Observed in PACU

- Eliminate all adverse events in the PACU including all nausea and vomiting
  - Reducing incidence in half would result in 4.8% reduction in mean nursing workload
  - Elimination of all adverse events would reduce overall mean length of stay by 6.7% among ambulatory surgery patients in 1999

Cohen MM et al. Anesthesiology 1999
Chung F, Mezei G. Anesth Analg 1999
Impact of Eliminating Adverse Events Observed in PACU

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➢ Reduce by 1.8% all types of patients in 2018

Cohen MM et al. Anesthesiology 1999
Chung F, Mezei G. Anesth Analg 1999
Liu S et al. J PeriAnesth Nurs 2020
Examples So Far Have Shown Four Broad Principles

• Reductions in time from anesthetic drugs
  – *Can* reduce costs, not do reduce costs

• Cost reductions, achieved from time reductions, are sensitive to characteristics of the facility studied:
  – Method of staff compensation
  – Average numbers of patients receiving care at the facility on that day of the week
  – Percentage of patients who would receive drug and benefit from time reduction
Examples So Far Have Shown Four Broad Principles

➢ Economics of drug sensitive to context of use
  – Mostly issue of patients not receiving drug

  – Method of staff compensation
  – Average numbers of patients receiving care at the facility on that day of the week
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Examples So Far Have Shown Four Broad Principles

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Examples So Far Have Shown Four Broad Principles

- Economics of drug sensitive to context of use
  - Mostly issue of patients not receiving drug

  ➢ As study a drug (or device), also investigate for future potential users what variables should be considered about each facility:
    - Method of staff compensation
    - Average numbers of patients receiving care at the facility on that day of the week
    - Percentage of patients who would receive drug and benefit from time reduction
Economics of Anesthetic Agents

- Reducing drug wastage is simplest
- Changing practice relies on individual feedback and appropriate case adjustment
- Choice of agent influences anesthetic times
- Translation of time into $ is sensitive to the percentage of costs that are fixed
- Predictions require simulation analysis

➢ Examples from ICU, **PACU**, and OR
  – Exceptions are changes in type of anesthesia
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    - Exceptions are changes in type of anesthesia
Fixed or Variable Cost of OR Time at 6 OR Surgical Suite

- A 6 OR ambulatory surgery center is staffed fully from 7 AM to 5 PM
- Average number of ORs in use, being cleaned, or being setup are as follows:
  - 1 PM: 6.0
  - 2 PM: 5.7
  - 3 PM: 4.9
  - 4 PM: 2.8
  - 5 PM: 0.3
Fixed or Variable Cost of OR Time at 6 OR Surgical Suite

- Ambulatory surgery center has more staffed hours than needed to complete the cases
  - Maybe to encourage increased volume
  - Maybe provides lowest possible costs
  - Maybe a collective bargaining agreement

- Regardless of why the staffing is as it is, reducing OR time will not reduce costs
Fixed or Variable Cost of OR Time at 6 OR Surgical Suite

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- Regardless of why the staffing is as it is, reducing OR time will not reduce costs

  ➢ In this example, OR staffing costs are a fixed cost of the number of ORs that are being run
Fixed or Variable Cost of OR Time at 6 OR Surgical Suite

- If the facility were to change staffing to be a mixture of 8 hr and 10 hr ORs,
  - By specialty by day of the week calculated based on maximizing the efficiency of use of OR time
- Then, reducing OR time would substantially reduce costs

McIntosh C et al. Anesth Analg 2006
More examples
www.franklindexter.net/Lectures/TurnoverTime.pdf
Dependency is Very Well Understood – Science is Mature

• Question showing little knowledge: “Does reducing OR time by 7 min save money?”
• Not because science is not well developed, but since conditions differ among facilities
  – Relationship can be predicted with each facility’s own data

McIntosh C et al. Anesth Analg 2006
Dependency is Very Well Understood – Science is Mature

- Principle that can be used for purposes of screening to decide whether to apply methods
  - For ORs with < 8 hr of cases, assume OR time is a fixed cost
  - For ORs with > 8 hr of cases, treat each reduction of 1 min OR time as resulting in savings of 1.1 min to 1.2 min of labor time

Dexter F et al. Anesth Analg 1999
Sevoflurane

Either

Desflurane
Sevoflurane

Either

Desflurane

Regular OR Schedule

Extended OR Schedule

Regular OR Schedule

7.5 Hours

Sevoflurane either or Desflurane

08:00 - 15:30
Regular OR Schedule

Extended OR Schedule

Regular OR Schedule

7.5 Hours

08:00

15:30

Sevoflurane

Either

Desflurane
Regular OR Schedule

Extended OR Schedule

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Economics of Anesthetic Agents

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Some Interventions’ Benefits So Big That No Need for Simulation

• Change the type of anesthesia performed
• Example
  – Phase I PACU bypass rate for monitored anesthesia care patients was 90% at multiple ambulatory surgery centers
  – Monitored anesthesia care also reduced drug administration versus general anesthesia

Apfelbaum JL et al. Anesthesiology 2002
More Local Anesthesia

- Hand surgery cases requiring no more equipment than 2 surgical trays and 1 all-inclusive “hand pack”
  - Example: endoscopic carpal tunnel release
- Local anesthesia cases’ non-surgical times (turnover + anesthesia-controlled time) averaged 18 minutes less than general anesthetic and 7 minutes less than monitored anesthesia care cases (both P < 0.001)

Caggiano NM et al. J Hand Surg Am 2015
More Regional Anesthesia

• At facilities where regional nerve block for one patient can be performed outside of OR while preceding case is being done

Gleicher Y et al. Reg Anesth Pain Med 2017
More Regional Anesthesia

- At facilities where regional nerve block for one patient can be performed outside of OR while preceding case is being done
  - Regional for outpatient knee surgery
  - Ways potentially to reduce costs
More Regional Anesthesia

- At facilities where regional nerve block for one patient can be performed outside of OR while preceding case is being done
- Regional for outpatient knee surgery
  - Drug costs are less [definitely no more]
  - Averaged 9 minutes less anesthesia controlled time than general anesthesia
  - 87% of patients bypassed phase I PACU

Williams BA et al. Anesthesiology 2000 and 2002
Dexter F et al. Periop Care Oper Room Manag 2023
Impact of the Reduced Anesthesia-Controlled Time

• 9 min ↓ anesthesia controlled time vs. GA
• No difference in surgical time versus GA
• Overall reduction unlikely large enough to reduce OR costs
• Definitely no increase in OR costs

Williams BA et al. Anesthesiology 2000
Impact of 87% of Patients Bypassing Phase I PACU

• Reduced costs not just by reducing time to discharge by 34 min, but by each nurse caring for 3 rather than 2 patients

• Such reductions more than enough to result in financially important reductions in PACU staffing costs when done on a long-term basis

Williams BA et al. Anesthesiology 2002
Dexter F et al. Anesth Analg 1999
Hospitals 100% Patients Bypass Because no Phase I PACU

- 16 successive patients for laparoscopic gynecologic surgery with endotracheal intubation for general anesthesia at typical Japanese hospital with no phase I PACU versus University of Iowa

Thenuwara KN et al. Can J Anesth 2018
Hospitals 100% Patients Bypass Because no Phase I PACU

- 16 successive patients for laparoscopic gynecologic surgery with endotracheal intubation for general anesthesia at typical Japanese hospital with no phase I PACU versus University of Iowa
- Every patient Shin-yurigaoka General Hospital had briefer time from end of surgery to ward than every such patient at University of Iowa (P < 0.001)

Thenuwarra KN et al. Can J Anesth 2018
Hospitals 100% Patients Bypass Because no Phase I PACU

End of Surgery to Ward (min)

OR Entrance to End of Surgery (hr)

- Iowa
- Tokyo
Hospitals 100% Patients Bypass Because no Phase I PACU

- While controlling for duration of surgery, estimated mean recovery time at the Tokyo hospital was 81.2% faster than at University of Iowa (95% CI 72.7% to 87.1%, P < 0.001)

Thenuwara KN et al. Can J Anesth 2018
Hospitals 100% Patients Bypass Because no Phase I PACU

- While controlling for duration of surgery, estimated mean recovery time at the Tokyo hospital was 81.2% faster than at University of Iowa (95% CI 72.7% to 87.1%, P < 0.001)

- BIS monitor, target-controlled propofol infusion, and remifentanil versus sevoflurane or isoflurane and hydromorphone

Thenuwara KN et al. Can J Anesth 2018
Hospitals 100% Patients Bypass Because no Phase I PACU

- Mean times from end of surgery to OR exit 1.9 minutes briefer at different Japanese hospital than University of Iowa (P < 0.0001)
- However, 100% of N=699 patients discharged from OR directly to surgical ward versus Iowa 97% of N=785 to phase I PACU, rest to ICU
  - No phase I PACU care even though all patients’ gynecological surgery duration $\geq$ 4 hours

Sugiyama D et al. Anesth Analg 2021
Hospitals 100% Patients Bypass Because no Phase I PACU

• Mean times from end of surgery to OR exit 1.9 minutes briefer at different Japanese hospital than University of Iowa (P < 0.0001)

• However, 100% of N=699 patients discharged from OR directly to surgical ward versus Iowa 97% of N=785 to phase I PACU, rest to ICU

➢ Prolonged extubations were 6% versus 39%, respectively, and same among subset patients with desflurane/remifentanil versus neither
Review – Summarize the Facts of the Talk
List Priorities to Monitor to Assess Anesthesia Efforts at Reducing Costs
List Priorities to Monitor to Assess Anesthesia Efforts at Reducing Costs

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  - Examples from ICU, PACU, and OR
  - Exceptions are changes in type of anesthesia
Additional Information on Operating Room Management

- [www.FranklinDexter.net/education.htm](http://www.FranklinDexter.net/education.htm)
  - Example reports with calculations
  - Lectures on day of surgery decision making, PACU staffing, OR allocation and staffing, anesthesia staffing, financial analysis, comparing surgical services among hospitals, and strategic decision making

- [www.FranklinDexter.net](http://www.FranklinDexter.net)
  - Comprehensive bibliography of peer reviewed articles in operating room and anesthesia group management