

# Economics of Anesthetic Agents

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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 other than from the University of Iowa, including no travel reimbursement or honorarium
  - I own no healthcare stocks (other than indirectly through mutual funds)
  - I have tenure with no incentive program

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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



# Reducing Fresh Gas Flow Rates Is Simple Conceptually

- Providing feedback to anesthesiologists 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



# 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

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



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  - 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 programs to reduce wastage of intravenous drugs using smaller syringes are simple to measure
  - Cost of pharmacy technician
  - Cost of extra syringes
  - Reduced wastage



# Example 1 of Reducing Wastage

- Which of the following provides the cheapest total cost?
  - Vecuronium 3 mg syringes
  - Vecuronium 5 mg syringes
  - Vecuronium 10 mg syringes
  - No way to know without doing inventory-control mathematics



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  - No way to know without doing 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



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  - Desflurane with 1.0 liter fresh gas flow
  
- It really is that simple conceptually



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# Education Alone Does Not Influence Anesthesia Providers

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

Schlunzen L et al. Acta Anaesthesiol Scand 1999

Wax DB et al. J Clin Anesth 2009



# Education Alone Does Not Influence Anesthesia Providers

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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

Schlunzen L et al. Acta Anaesthesiol Scand 1999

Wax DB et al. J Clin Anesth 2009

Snyder-Ramos SA et al. Der Anaesthesist 2003

Horrow JC, Rosenberg H. Can J Anaesth 1994



# 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

Junger A et al. Anesth Analg 2001

Apfel CC et al. Anesthesiology 1999



# 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%

Overdyk FJ et al. J Clin Anesth 1999

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

Duncan PG et al. Can J Anaesth 2001



# 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)



# 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 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,  $P < 0.0001$ )

Epstein RH et al. Anesth Analg 2009

Dexter F et al. Anesth Analg 2010



# 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)
- Examples using desflurane
  - Reduces incidence 75% versus sevoflurane
  - Reduces incidence 95% versus isoflurane

Dexter F et al. Anesth Analg 2010

Agoliati A et al. Anesth Analg 2010



# Provider Specific Feedback Can Also Include Time

- Ambulatory surgery center
  - 1000 general anesthetics per year ×  
5% rate of prolonged extubation times  
= 4 events per month
  - 75% reduction results in 1 event per month
- Hospital
  - 750 general anesthetics per year ×  
20% rate of prolonged extubation times  
= 3 events per week
  - 95% reduction results in < 1 per month

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# Why Does It Matter That Drugs Influence Anesthetic Times?

Get your anesthesia  
performance on the  
fast track.

 **Suprane**  
desflurane, USP  
*THE FAST TRACK ANESTHETIC™*



# Why Does It Matter 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



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Apfelbaum JL et al. Anesth Analg 1993



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

Dexter F et al. Anesth Analg 2007



# Why Does It Matter 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.”

Vitez TS, Macario A. J Clin Anesth 1998



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- For example, as expected, mean score 4.0 for “ability to calmly manage a crisis.”
- Mean score 3.9 for “patient quick to awaken.”

Vitez TS, Macario A. J Clin Anesth 1998



# 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
  - TSI (Eclipsys) cost accounting system
- Desflurane reduces time to following commands by an average of 2.5 minutes
- Savings = \$50 per case
  - $\$50 = \$20 \text{ per min} \times 2.5 \text{ min per case}$

Dexter F et al. Anesthesiology 2002



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- Savings = \$50 per case
  - $\$50 = \$20 \text{ per min} \times 2.5 \text{ min per case}$
  - Absurd! Use of desflurane did not save \$50



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# Operating Room Labor is a Step Cost

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OR time  $\cong$  (cost of the patient care labor)  $\div$   
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- 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

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OR time  $\cong$  (cost of the patient care labor)  $\div$   
(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



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- 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
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# *Long-Term* Change in Practice by Many Anesthesiologists

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# Example 1 of Cardiac Surgery Scenario

- Dr. Jones is a cardiac anesthesiologist
- After off-pump CPB, extubation right away
  - Unusually fast achieved with remifentanil
- Patient leaves ICU early that evening
- Have ICU nursing costs been reduced?



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- Dr. Jones is a cardiac anesthesiologist
- After off-pump CPB, extubation right away
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- Patient leaves ICU early that evening
- Have ICU nursing costs been reduced?
  - Generally ***not***, because ICU nurses are scheduled a month or so ahead of time



# 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
- Have ICU nursing costs been reduced?

Straka Z Ann Thorac Surg 2002



# 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
- Have ICU nursing costs been reduced?
  - It depends on characteristics of the ICU



# This is Why Computer Simulation is Needed

- Purpose of the computer simulations
  - Determine whether or not a reduction in staffing costs can likely be achieved
  - There is no one answer to this question, because depends on ...
    - Whether costs are fixed, varying among sites
    - Cost of drug, which varies among sites



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# 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
- What data are needed for a formulary committee to decide whether this result would apply to its hospital?



# Sensitivity of Early Extubation Results to ICU Characteristics

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

Dexter F et al. J Clin Anesth 1998



# Sensitivity of Early Extubation Results to ICU Characteristics

- 830 per year  $\cong$  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

- 830 per year  $\cong$  3-4 elective CABG per day
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  - 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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# 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

- How can you 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
- Large potential cost reduction?



# Impact of Nausea and Vomiting

- Implications

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

$$3.4\% = (69\% \text{ receiving general} \times 8\% \text{ of those receiving general having nausea and/or vomiting}) \times (63\% \text{ prolongation of length of stay})$$



# 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
- 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%

Cohen MM et al. Anesthesiology 1999

Chung F, Mezei G. Anesth Analg 1999



# Examples So Far Have Shown Four Broad Principles

- Reductions in time from changing anesthetic drugs *can*, not do, reduce costs
- Cost reductions achieved from time reductions are sensitive to the following characteristics of the site studied:
  - Method of staff compensation
  - Average numbers of patients receiving care at the site on that day of the week
  - Percentage of patients that will receive the benefit of time reduction



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# How Many Sites Are There in 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	4 PM	2.8
2 PM	5.7	5 PM	0.3
3 PM	4.9		
- Would reducing OR time reduce costs?



# How Many Sites Are There in 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



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  - 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
- In this example, OR staffing costs are a fixed cost of the number of ORs that are being run



# How Many Sites Are There in 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](http://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

More examples [www.franklindexter.net/Lectures/TurnoverTime.pdf](http://www.franklindexter.net/Lectures/TurnoverTime.pdf)

# 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

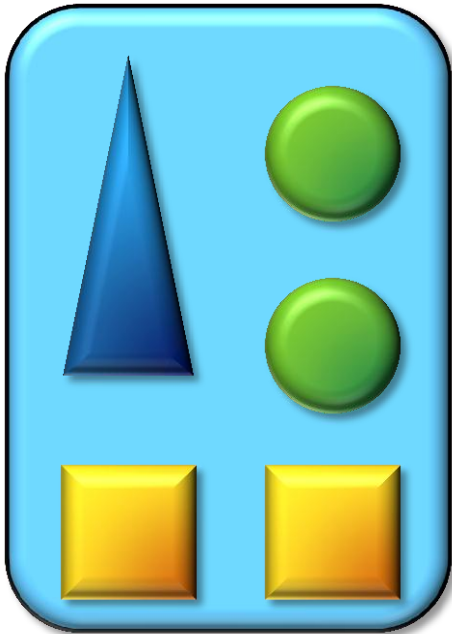
Dexter F et al. Anesth Analg 1999

Dexter F et al. Anesth Analg 2009 & 2010



**Regular  
OR Schedule**

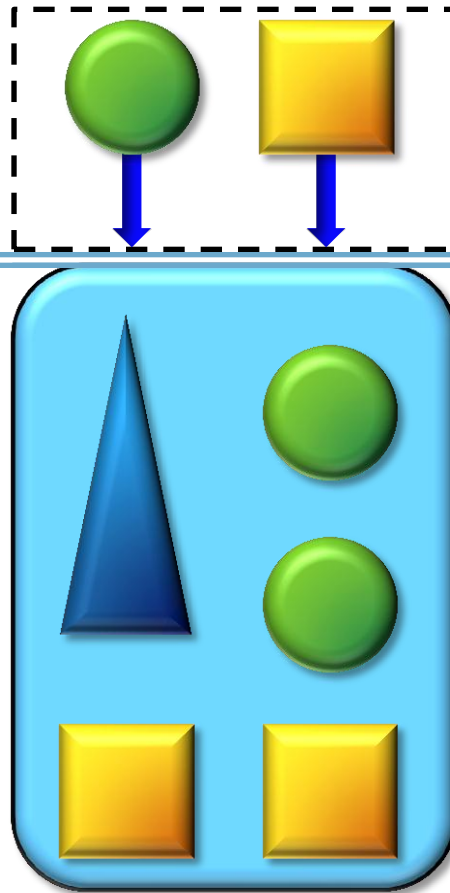
15:30  
7.5 Hours  
08:00



**Sevoflurane**

**Extended  
OR Schedule**

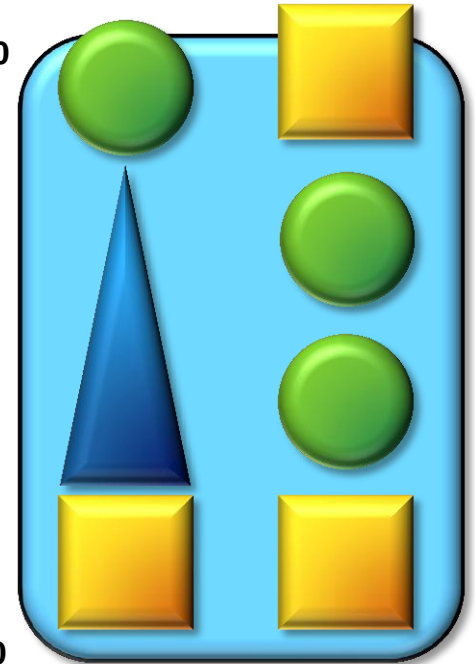
15:30  
7.5 Hours  
08:00



**Sevoflurane**

**Regular  
OR Schedule**

15:30  
7.5 Hours  
08:00



**Desflurane**

# 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

# 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 Regional Anesthesia

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

# 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

# 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

Dexter F et al. Anesth Analg 1995, 2003

Dexter F et al. Reg Anesth Pain Med 1998

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 switching from 1:2 to 1:3 staffing
- 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



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# 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