Controversies in Prevention of Surgical Site Infections

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Objectives

- To discuss the incidence of surgical site infections (SSI) following elective colorectal surgery.
- To review strategies to limit SSIs
- To review current national initiatives and standards of care for the prevention of SSIs

SSI Rates After Colorectal Surgery

Risk Index	No. of infections	Infection rates, %	NNIS rates, %	*P*
0	9	6.7	4.3	0.19
1	14	6.9	6.5	0.77
2	12	9.8	10.5	0.88
3	8	30.8	13.9	0.04

* NNIS = National Nosocomial Infections Surveillance. Weiss et al. *Arch Surg* 1999;134:1041–1048.

Factors That Increase Risk of Infections After Colorectal Surgery

- Rectal resection vs intraperitoneal colon resection
- Operations lasting ≥3.5 hours
- Impaired host defenses
- Age >60 years
- Hypoalbuminemia
- Poor preoperative bowel preparation
- Bacterial contamination of surgical incision
- Corticosteroid therapy
- Malignant disease

Am J Health-Syst Pharm 1999;56:1839–1888.

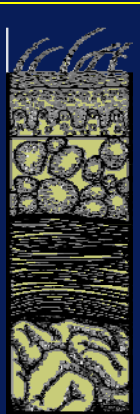
Defining Surgical Site Infections

Superficial incisional
(skin or subcutaneous tissue)

- Infection ≤30 days after procedure and at least 1 of the following:
  - Purulent drainage from superficial lesion/organisms isolated aseptically
  - At least 1: pain/tenderness, swelling, redness, heat
  - Superficial incision deliberately opened by surgeon unless culture negative
- *or* SSI diagnosed by surgeon or attending physician

Horan TC et al. *Infect Control Hosp Epidemiol.* 1992;13:606–608. Figure reproduced with permission.

Defining Surgical Site Infections *(cont.)*



Deep incisional
(deep soft tissue at incision site)

- Infection ≤30 days after procedure (no implant) or ≤1 year (with implant) plus at least 1 of of the following:
  - Purulent drainage from deep in incision but not from organ/space
  - Spontaneous dehiscence or surgical opening of deep incision with fever, pain, or tenderness
  - Abscess or other evidence of infection involving deep incision
- *or* SSI diagnosed by surgeon or attending physician

Horan TC et al. *Infect Control Hosp Epidemiol.* 1992;13:606–608. Figure reproduced with permission.

Defining Surgical Site Infections *(cont)*

Organ/space
(any site other than incision)

- Infection ≤30 days after procedure (no implant) or ≤1 year (with implant) plus at least 1 of the following:
  - Purulent drainage from a drain placed through a stab wound into organ/space
  - Organisms isolated from a culture of fluid or tissue
  - Abscess or other evidence of infection involving the organ/space found by histopathologic examination, X-ray, or reoperation
- *or* SSI diagnosed by surgeon or attending physician

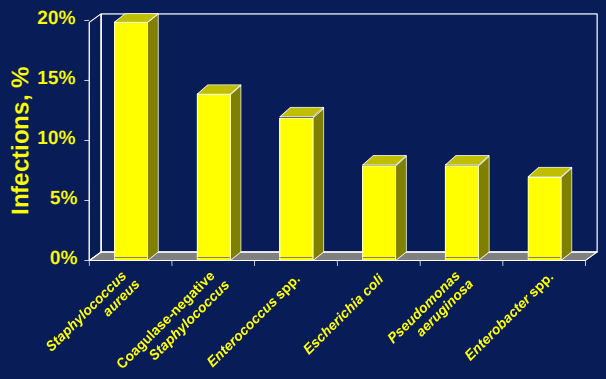
Horan TC et al. *Infect Control Hosp Epidemiol.* 1992;13:606–608. Figure reproduced with permission.

Surgical Wound Classification

- **Class 1 – Clean**
  - Uninfected operative wound, no inflammation
- **Class II – Clean-Contaminated**
  - Alimentary tract (and others), under controlled conditions without unusual contamination
- **Class III – Contaminated**
  - Major breaks in sterile technique, eg, gross spillage from the gastrointestinal tract
  - Incisions encountering acute inflammation
- **Class IV – Dirty-Infected**
  - Old traumatic wounds with dead tissue, infection, perforated viscera

Mangram AJ et al. *Am J Infect Control.* 1999;27:97–134.

Major Pathogens in SSI



NNIS Report. *Am J Infect Control.* 1996;24:380–388.

Strategies to Limit SSIs

History of Antibiotic Prophylaxis in Colorectal Surgery

1961: Animal studies by Burke demonstrated the importance of timing in preventing dermal or incisional infection.[1]

1969: Landmark study by Polk and Lopez-Mayor demonstrated a significant reduction of wound and intraabdominal sepsis among patients treated with antimicrobial prophylaxis.[2]

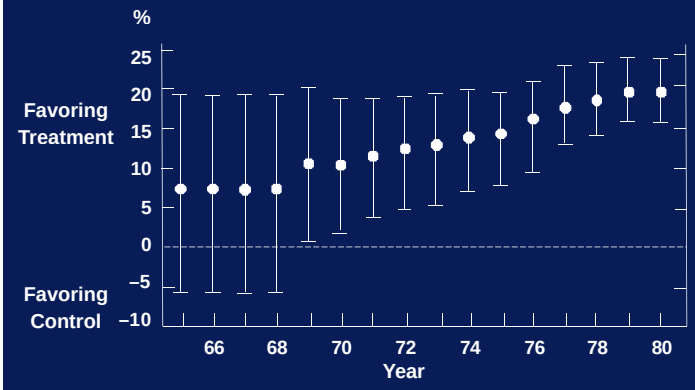
1970s: Key Veterans' Affairs trials showed benefit of antibiotic prophylaxis over placebo in elective CRS
- 9% wound infection rate in antibiotic-treated patients vs 35% in placebo group[3]
- Infection in 0 of 69 patients receiving neomycin-erythromycin base vs 3 of 16 patients receiving mechanical preparation only[4]

1981: Baum and colleagues recommended elimination of "no-treatment" control groups in trials of antibiotic prophylaxis in colon surgery[5]

1998: Song and Glenny review of 147 trials between 1984 and 1995.[6]

1. Burke JF. *Surgery.* 1961;50:161–167.
2. Polk HC Jr, et al. *Surgery.* 1969;66:97–103.
3. Clarke JS, et al. *Ann Surg.* 1977;186:251–258.
4. Nichols RL, et al. *Ann Surg.* 1973;178:453–459.
5. Baum ML, et al. *N Engl J Med.* 1981;305:795–799.
6. Song F, et al. *Br J Surg.* 1998;85:1232–1241.

Antibiotic Prophylaxis in CRS



Baum et al. *N Engl J Med* 1981;305:795–799.

Importance of Timing of Surgical Antimicrobial Prophylaxis

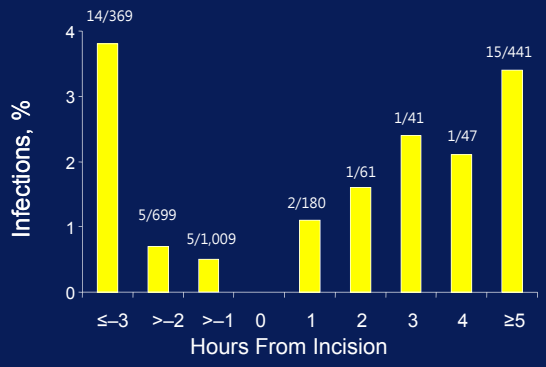
Temporal relation between the administration of prophylactic antibiotics and rates of surgical-wound infection

Time of Administration	No. of patients	No. (%) of infections	Odds ratio
Early (2–24 hours before incision)	369	14 (3.8)	4.3*
Preoperative (0–2 hours before incision)	1,708	10 (0.59)	1.0
Perioperative (≤3 hours after incision)	282	4 (1.4)	2.1†
Postoperative (>3 hours after the incision, but <24 hours after surgery)	488	16 (3.3)	5.8‡

* *P*= 0.001. † *P*=0.23. ‡ *P*=0.0001. NA = not applicable.

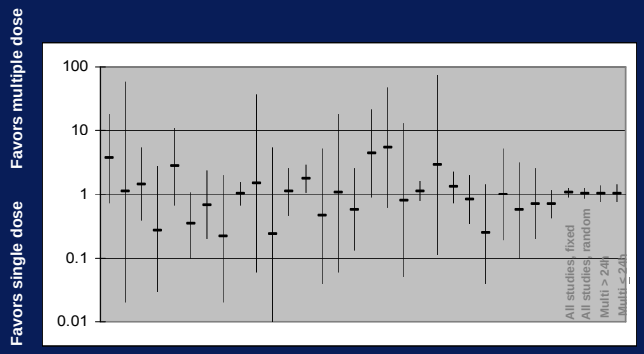
Classen et al. *N Engl J Med*. 1992;326:281–286.

Perioperative Prophylactic Antibiotics: Timing of Administration



Classen DC et al. *N Engl J Med*. 1992;326:281–286. Copyright © 1992 Massachusetts Medical Society. All rights reserved.

Single- vs Multiple-Dose Surgical Prophylaxis: Systematic Review



McDonald M et al. *Aust NZ J Surg*. 1998;68:388–396. Adapted with permission from Blackwell Synergy © 1998.

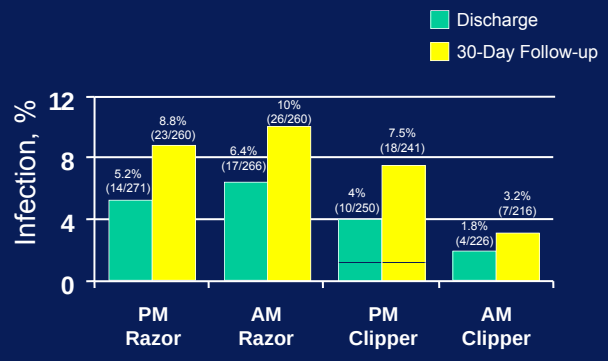
Impact of Prolonged Antibiotic Prophylaxis Cardiac Surgery

- 2,641 patients undergoing CABG
  - Group 1 <48 hours of antibiotics
  - Group 2 >48 hours of antibiotics
- SSI rates
  - Group 1 9% (131/1,502)
  - Group 2 9% (100/1,139)
  - Odds ratio 1.0 (95% CI: 0.8–1.3)
- Increased antibiotic resistant pathogens – Group 2
  - Odds ratio 1.6 (95% CI: 1.1–2.6)

CABG = coronary artery bypass grafting; CI = confidence interval.

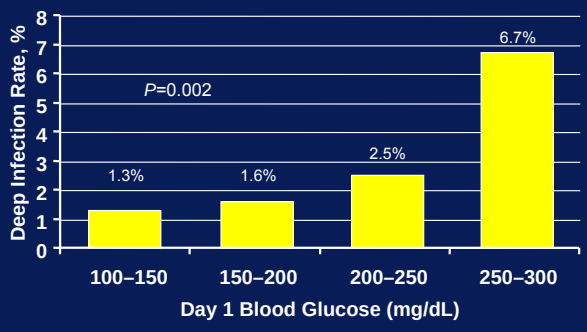
Harbarth S et al. *Circulation*. 2000;101:2916–2921.

Hair-Removal Techniques and SSIs



Alexander JW et al. *Arch Surg*. 1983;118:347–352.

SSIs and Glucose Concentrations



Zerr KJ et al. Glucose control lowers the risk of wound infection in diabetics after open heart operations, page 360. Reprinted from *The Annals of Thoracic Surgeons*, Vol. 63. Copyright 1997, with permission from the Society of Thoracic Surgeons. All rights reserved.

SSIs and Glucose Concentrations *(cont)*

- 1,000 cardiothoracic surgery patients with preoperative hemoglobin A1c (HbA1c) levels measured
  - 300 known diabetic patients
  - 42 with undiagnosed diabetes
- Incidence of SSI
  - Diabetes (known and undiagnosed) 5.8% (20/342)
  - Without diabetes 1.5% (10/658)
  - Diabetes with HbA1c ≥8% 7.9% (10/126)
  - Diabetes with HbA1c <8% 4.0% (7/174)

Latham R et al. *Infect Control Hosp Epidemiol.* 2001;22:607–612.

SSIs and Glucose Concentrations *(cont)*

Glucose level (mg/dL)	Infected patients (n=72)	Noninfected patients (n=902)	Odds ratio
<200 (referrent)	35 (49%)	651 (72%)	1.00
200–249	21 (29%)	154 (17%)	2.54
250–299	11 (15%)	69 (8%)	2.97
≥300	5 (7%)	28 (3%)	3.32

Latham R et al. *Infect Control Hosp Epidemiol.* 2001;22:607–612. Adapted with permission from the University of Chicago Press © 2001.

Perioperative Normothermia

- 200 CRS patients
  - Control: Routine intraoperative thermal care (mean temperature 34.7˚C)
  - Treatment: Active warming (mean temperature 36.6˚C)
- Incidence of SSI
  - Control 19% (18/96)
  - Treatment 6% (6/104); *P*=0.009

Kurz A et al. *N Engl J Med.* 1996;334:1209–1215.

Supplemental Oxygen

- 500 CRS patients
  - 80% or 30% inspired oxygen during operation and for 2 hours post surgery
  - All patients received prophylactic antibiotics
- Results
  - Arterial and subcutaneous P_{O_2} higher in 80% oxygen group
  - Lower incidence of SSIs with higher supplemental oxygen (5.2% vs 11.2%; *P*=0.01)

Greif et al. *N Engl J Med.* 2000;342:161–167.

Preoperative Strategies to Limit SSIs: Skin Surface Preparations

- Antiseptic showers
  - Reduced bacterial counts by 3.5 $\log_{10}$ from baseline[1]
  - No evidence that they affect SSIs[2]
- Skin preparation in the operating room (OR)
  - Usually iodophors, alcohol-containing products, or chlorhexidine gluconate[2]

1. Seal LA et al. *Am J Infect Control.* 2004;32:57–62.
2. Mangram AJ et al. *Am J Infect Control.* 1999;27:97–134.

Mechanical Bowel Preparation vs. No Preparation

Infectious complication rate in randomized, prospective studies of mechanical bowel preparation (prep) vs no preparation (nonprep).

Authors	Wound Infection		Intraabdominal Infection		Anastomotic Leak	
	Prep	Nonprep	Prep	Nonprep	Prep	Nonprep
Brownson et al (N=179)[1]	5.8	7.5	9.3*	2.2*	12*	1.5*
Burke et al (N=186)[2]	4.9	3.4	NS	NS	3.7	4.6
Santos et al (N=149)[3]	24*	12*	NS	NS	10	5
Miettinen et al (N=267)[4]	4	2	2	3	4	2

NS = not specified; * *P*<0.05.

Adapted with permission from Zmora O et al. Bowel preparation for colorectal surgery. *Dis Colon Rectum.* 2001;44:1537–1549. Table 1. Copyright © 2001 Springer Science and Business Media.

1. Brownson P et al. *Br J Surg.* 1992;79:461–462.
2. Burke P et al. *Br J Surg.* 1994;81:907–910.
3. Santos JC Jr et al. *Br J Surg.* 1994;81:1673–1676.
4. Miettinen RP et al. *Dis Colon Rectum.* 2000;43:669–677.

Mechanical Bowel Preparation vs. No Preparation *(cont)*

Authors	Wound Infection		Anastamotic Leak		Intraabdominal Infection	
	Prep	Nonprep	Prep	Nonprep	Prep	Nonprep
Fa-Si-Oen et al[1]	7.2%	5.6%	5.6%	4.8%	NA	NA
Bucher et al[2]	12.8%	4.0%	6.4%	1.3%	1.3%	2.7%

1. Fa-Si-Oen P et al. *Dis Colon Rectum*. 2005;48:1509–1516.
2. Bucher P et al. *Br J Surg*. 2005;92:409–414.

Preoperative Oral Antibiotic Bowel Preparation to Limit SSIs *(cont)*

2002 meta-analysis of 13 RCTs in elective CRS

- Compared combination oral and systemic antimicrobial prophylaxis vs systemic alone
- Results:
  - Combined oral and systemic patients had significantly fewer SSIs
    - Difference in SSI 0.56 (95% CI, 0.26–0.86)
    - Relative risk 0.51 (95% CI, 0.24–0.78); *P*<0.001
  - Oral antibiotics add value by reducing bacteria in the colon

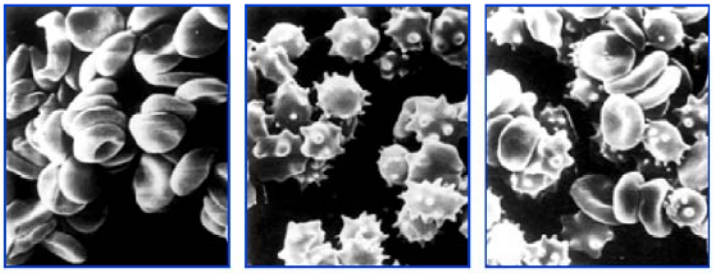
RCT = randomized controlled trial.
Lewis RT. *Can J Surgery*. 2002;45:173–180.

1984-1995 Analysis of CR Surgery Prophylaxis Trials

- Literature search to identify RCTs published between 1984 and 1995 for antimicrobial prophylaxis in prevention of postoperative surgical site infection (SSI) in CRS
- 147 trials identified with 70 antibiotic regimens
- Overall rate of SSIs: 11%
  - SSI with single-dose regimens ranged from 1.9–31.8% (mean 11.5%; N=19–119)
- No significant overall difference in the rate of SSIs among many different regimens; however, some regimens may be inadequate

Song F, Glenny AM. *Br J Surg* 1998;85:1232–1241.

Age of Blood



Scanning electron micrographs of red blood cells isolated from stored blood on Day 1, Day 21, and Day 35. During storage, the shape of RBCs changed gradually from normal discoid to echinocytes (dented or shriveled red cells).
Reproduced with permission from: Hovav et al. *Transfusion*. 1999;39:277-281.

Initiatives and Standards of Care to Prevent Surgical Site Infections

Medicare Surgical Infection Prevention (SIP) Project Objective

To decrease the morbidity and mortality associated with postoperative infection in the Medicare patient population

Bratzler DW. Available at: http://www.medqic.org/scip/pdf/spkrnotesSIP_to_SCIP_101205.ppt. Accessed May 26, 2006.

Selected Surgical Procedures

- Cardiac
  - CABG
- Colon
- Hip and knee arthroplasty
- Abdominal and vaginal hysterectomy
- Vascular surgery
  - Aneurysm repair
  - Thromboendarterectomy
  - Vein bypass

Bratzler DW. Available at: http://www.medqic.org/scip/pdf/spkrnotesSIP_to_SCIP_101205.ppt. Accessed May 26, 2006.

Antibiotic Recommendation Sources

- American Society of Health-System Pharmacists
- Infectious Diseases Society of America
- The Hospital Infection Control Practices Advisory Committee
- Medical Letter
- Surgical Infection Society
- Sanford Guide to Antimicrobial Therapy 2003

Bratzler DW. Available at: http://www.medqic.org/scip/pdf/spkrnotesSIP_to_SCIP_101205.ppt. Accessed May 26, 2006.

Antimicrobial Requirements

- Active against most likely aerobes and anaerobes[1,2]
- Appropriate dosage and timing for adequate concentration at wound site[1,2]
- Generally well tolerated[1]
- Administer for shortest effective period to minimize adverse effects, cost, and resistance[1]

1. American Society of Health-System Pharmacists. *Am J Health-Syst Pharm* 1999;56:1839–1888.
2. Song et al. *Br J Surg* 1998;85:1232–1241.

SIP Program Quality Indicators

- Quality Indicator No. 1
  - Proportion of patients who receive antibiotics within 1 hour before surgical incision
- Quality Indicator No. 2
  - Proportion of patients who receive prophylactic antibiotics consistent with current recommendations
- Quality Indicator No. 3
  - Proportion of patients whose prophylactic antibiotics were discontinued within 24 hours of surgery end time

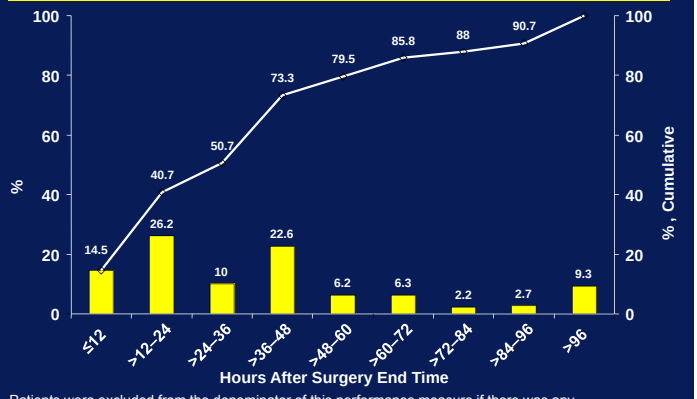
Bratzler DW. Available at: http://www.medqic.org/scip/pdf/spkrnotesSIP_to_SCIP_101205.ppt. Accessed May 26, 2006.

SIP Program: Performance Stratified by Surgery, January 1 – November 30, 2001

Type of surgery	Antibiotic given within 1 hr, %	Correct antibiotic, %	Antibiotic stopped within 24 hr, %	Median time to dis-continuation (hr)
Cardiac	58.5	95.1	34.4	40.9
Vascular	47.0	91.5	45.2	42.7
Hip/knee	59.7	97.2	36.7	39.0
Colon	46.0	75.8	40.8	57.0
Hysterectomy	54.8	90.2	77.9	21.4
All operations	55.7	92.6	40.7	40.4

Bratzler et al. *Arch Surg.* 2005;140:174–182.

Discontinuation of Antibiotics



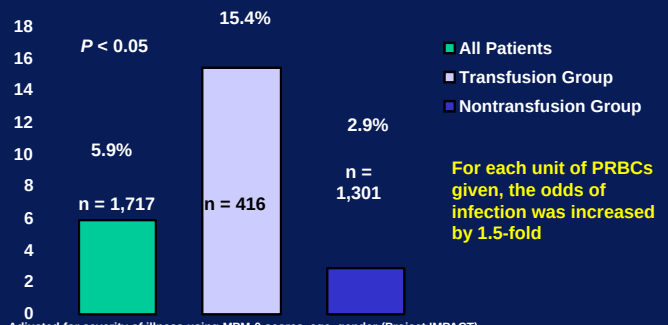
Patients were excluded from the denominator of this performance measure if there was any documentation of an infection during surgery or in the first 48 hours after surgery.
Bratzler DW et al. *Arch Surg.* 2005;140:174–182. Reproduced with permission from the American Medical Association © 2005.

Transfusion and Perioperative Infection

- Koval et al. J Orthop Trauma 1997;11:260-266.
- 687 geriatric Pts. undergoing ORIF hip fracture
- 27% postop infection rate transfused vs. 15% non-transfused
- Effect present on multivariable analysis
- Houbiers JG, et al. Transfusion. 1997;37:126-34.
- 697 undergoing surgery for colorectal cancer
- 39% postop infection rate transfused vs. 24% non-transfused
- Relative risk 1.6 for 1-3 U; 3.6 for >3 U

ORIF = open reduction internal fixation.

The Impact of PRBCs on Nosocomial Infection Rates in ICU



Adjusted for severity of illness using MPM-0 scores, age, gender (Project IMPACT). Taylor et al. *Crit Care Med* 2002;30:2249-2254.

Evolution of SIP to SCIP

Surgical Care Improvement Project (SCIP)

- National partnership of organizations committed to improving the safety of surgical care through the reduction of postoperative complications.
- Goal:
  - Reduce surgical complications by 25% by 2010
- Focus on 4 broad areas where the incidence and cost of complications are high:
  - Surgical site infections
  - Adverse cardiac events
  - Deep vein thrombosis
  - Postoperative pneumonia

Medicare Quality Improvement Community. Available at:http://www.medqic.org/SCIP. Accessed June 21, 2006.

SCIP *(cont)*

Measures specific to surgical prophylaxis:

- Prophylactic antibiotics received within 1 hour prior to surgical incision
- Appropriate prophylactic antibiotic selection for surgical patients
- Prophylactic antibiotics discontinued within 24 hours after surgery end time
- Postoperative serum glucose 6 AM control in cardiac patients
- Appropriate hair removal
- Immediate postoperative normothermia for CRS patients
- Postoperative wound infection diagnosed during index hospitalization

Bratzler DW. Available at: http://www.medqic.org/scip/pdf/spkrnotesSIP_to_SCIP_101205.ppt. Accessed May 26, 2006.

SCIP Summary

- Substantial opportunities remain to improve outcomes from surgery
- There is a national commitment to performance measurement and improvement of surgical outcomes
- Through a broad national partnership, hospitals across the nation will be encouraged to participate in activities to reduce the complications of surgery in the United States

Bratzler DW. Available at: http://www.medqic.org/scip/pdf/spkrnotesSIP_to_SCIP_101205.ppt. Accessed May 26, 2006.

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