A COMPUTERIZED REMINDER FOR PROPHYLAXIS OF DEEP VEIN THROMBOSIS IN SURGICAL PATIENTS

by

Robert Patterson

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SUPERVISORY COMMITTEE APPROVAL

of a thesis submitted by

Robert Patterson

This thesis has been read by each member of the following supervisory committee and by majority vote has been found to be satisfactory.

Chair: Reed M. Gardner

C. Gregory Elliott

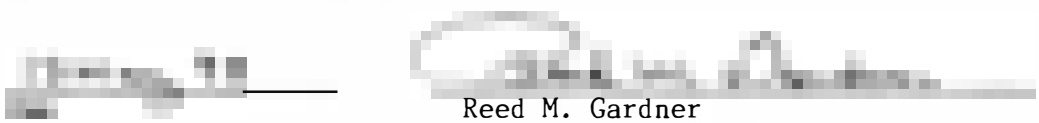
John W. Williamson

THE UNIVERSITY OF UTAH GRADUATE SCHOOL

FINAL READING APPROVAL

To the Graduate Council of the University of Utah:

I have read the thesis of Robert Patterson in its final form and have found that (1) its format, citations, and bibliographic style are consistent and acceptable; (2) its illustrative materials including figures, tables, and charts are in place; and (3) the final manuscript is satisfactory to the supervisory committee and is ready for submission to The Graduate School.



Reed M. Gardner
Chair, Supervisory Committee

Approved for the Major Department

Reed M. Gardner
Chair/Dean

Approved for the Graduate Council

Ann W. Hart
Dean of The Graduate School

ABSTRACT

The objective of the study was to develop a computerized reminder system to ensure that preoperative deep vein thrombosis (DVT) prophylaxis (anticoagulation or compression devices) was provided for eligible patients. The study design was a prospective trial with historic controls. The setting was LDS Hospital in Salt Lake City, Utah, a tertiary care teaching center. The alternate hypothesis stated that a computerized reminder system would increase the rate of DVT prophylaxis in surgical patients. A local consensus was developed among surgeons as to which procedures should receive DVT prophylaxis. The historic rate of DVT prophylaxis was measured for these procedures at 83.8% (794 of 948 eligible cases). A computerized reminder system was implemented on the hospital's computer system, which flagged patients scheduled for a procedure for which DVT prophylaxis was indicated. The rate of DVT prophylaxis was then remeasured. For the 3 months after the introduction of the reminder, compliance with DVT prophylaxis rose to 99.3% (1118 out of 1126 eligible cases). Fourteen of 54 types of procedures showed statistically significant improvement in the rate of DVT prophylaxis between the study group and the historic controls. The procedures which did not show improvement had a small number of cases ($n<8$) or else were already at a high level of prophylaxis (prophylaxis rate>90%). When individual procedures were combined into groups of similar surgeries, 7 of 10 groups showed statistically significant improvement. Similarly, 3 of 4 surgical divisions showed statistically significant

improvement. For all cases combined, the rate of DVT prophylaxis showed highly significant improvement ($p<.001$) between the historic controls (83.8%) and the study group (99.3%). The conclusion of the study was that a computerized reminder appeared to be an effective method of increasing the rate of DVT prophylaxis in surgical patients.

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LIST OF ACRONYMS AND ABBREVIATIONS

ABNA	Achievable Benefit Not Achieved
abx	antibiotics
ACCP	American College of Chest Physicians
APR	Abdominal Perineal Resection
b.i.d.	Latin for 'twice in a day'
BSO	Bilateral Salpingo-Oophrectomy
CME	Continuing Medical Education
CQI	Continuous Quality Improvement
D&C	Dilation and Curettage
DVT	Deep Vein Thrombosis
EDW	Enterprise Data Warehouse
ES	Elastic Stockings
FFP	Fresh Frozen Plasma
FTP	File Transfer Protocol
GYNE	Gynecological
HELP	Health Evaluation through Logical Processing
HIT	Heparin Induced Thrombocytopenia
H_O	null hypothesis

H_1	alternate hypothesis
ICD9	International Classification of Disease, 9th edition
ICOPER	International Cooperative Pulmonary Embolism Registry
ID	Identification
IHC	Intermountain Health Care
INR	International Normalized Ratio
IORT	Intra-Operative Radiation Therapy
IPC	Intermittent Pneumatic Compression
IRB	Internal Review Board
IV	intravenous
lap	laparoscopic
lap chole	laparoscopic cholecystectomy
LDS	Latter Day Saint
LDSH	Latter Day Saint Hospital
LDUH	Low Dose Unfractionated Heparin
LMWH	Low Molecular Weight Heparin
MAS	Minimum (or Maximum) Acceptable Standard
mg	milligram
NS	Not Significant
OR	Operating Room
ORIF	Open Reduction Internal Fixation

p	probability
PAL	PTXT Application Language
PE	Pulmonary Embolism
PEG	Percutaneous Endoscopic Gastostomy
proph	Prophylaxis
pt	patient
PTT	Partial Thromboplastin Time
PTXT	Pointer to Text
QA	Quality Assurance
QI	Quality Improvement
SCD	Sequential Compression Device
SQL	Standard Query Language
TAH	Total Abdominal Hysterecomy
TAL	Tandem Application Language
TURP	Trans Urethral Resection of Prostate

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I wish to thank my graduate committee - Dr. Reed Gardner, Dr. Greg Elliott, and Dr. John Williamson - for the wisdom of their many insights and the time they took to guide my efforts. Thanks also to Dr. Don Doty for all of his support and encouragement during my stay in Salt Lake City. Thanks to Kyle Johnson, who guided me through the intimidating jungle of PAL programming.

I. INTRODUCTION

Purpose of Study

The purpose of the study was to use the relatively new discipline of medical informatics to solve an old problem-preventing thromboembolism in surgical patients. Surgery of any type is not without risks and complications. Postsurgical thromboembolic disease, presenting as either deep vein thrombosis or pulmonary embolism, can be an unintended yet devastating byproduct of surgery. As the old aphorism states, an ounce of prevention is worth a pound of cure, and prophylaxis of thromboembolism is vital for certain surgical procedures. The study's goal was to develop a computerized reminder system to ensure that appropriate preoperative prophylaxis was ordered for eligible patients.

The Problem of Venous Thromboembolism

Venous thromboembolism is the abnormal presence of stationary blood clots (thrombus) or free floating clots (embolism) in the veins. When the blood clot occurs in the major named veins, the disease is referred to as deep vein thrombosis (DVT). If a blood clot breaks free, it may travel through the venous system to the heart and then impact in the lungs, causing the serious disease known as pulmonary embolism (PE).

The initial thrombus is caused by 1 or more of 3 factors - circulatory stasis, endothelial injury, and abnormal coagulation - which together are known as Virchow's

triad (1). During a surgical procedure, patients are placed at risk of venous thrombosis. General anesthetic causes vessels to dilate and circulation to slow, leading to stasis. The veins themselves may be directly damaged, either through trauma preceding the surgery or injury during the surgical procedure. Finally, surgical patients may be hypercoaguble from medications or disease processes such as cancer.

Deep vein thrombosis may be asymptomatic or the patient can develop local problems in the lower limbs, such as varicose veins and skin ulcers. More serious complications arise if the thrombus progresses to an embolus; i.e., the clot breaks free from the leg and travels through the heart to the lungs, causing a pulmonary embolism. A PE may impede the flow of blood to the lungs and cause difficulties with oxygenation. Whereas some cases of PE may be asymptomatic, others present more dramatically and require hospitalization and anticoagulant therapy. Unfortunately, in many cases the initial presentation of a PE is sudden death (2-4).

Not surprisingly, venous thromboembolism has been extensively examined in the medical literature. DVT and PE have been studied in different populations, such as the elderly, cancer patients, trauma victims and surgical patients (5-18). A recurrent theme in many studies is that the diagnosis is often missed and the consequences can be fatal (19-21).

In the recent Fourth American College of Chest Physicians (ACCP) Consensus Conference on Antithrombotic Therapy (2), the magnitude of the problem was outlined. Pulmonary embolism causes the death of 100,000 patients each year in the United States (22). Fatal PE may be the most common preventable cause of hospital death (23). Yet, despite the proven efficacy of prevention, prophylaxis for deep thromboembolism is

underutilized and in one study of 2,000 patients with multiple risk factors for thromboembolism, only one third received prophylaxis (24).

Prevention of Venous Thromboembolism

When properly used, prophylaxis can substantially reduce the incidence of thromboembolic disease in the surgical patient. Prevention of DVT has been extensively studied for decades, with prophylaxis in most studies consisting of sequential compression devices (SCDs) or anticoagulant therapy. SCDs are inflatable stockings wrapped around the leg during surgery. At regular intervals they fill with air and then empty. The legs are squeezed when the stockings fill, which promotes venous circulation. SCDs are also referred to as intermittent pneumatic compression stockings (IPCs), or they may be known by a trade name, such as Plexipulse.

Low dose unfractionated heparin (LDUH) and coumadin are anticoagulants which interfere with the normal coagulation pathways, resulting in decreased clot formation. Recently, low molecular weight heparin (LMWH) has come under increasing scrutiny as an anticoagulant which may be as effective as LDUH yet have fewer bleeding complications (25-36). With so many studies of different agents, no one regimen has proven superior. Recommendations for prophylaxis often list several options (2,37-49).

For some procedures, such as spinal surgery, investigators have not been able to arrive at a consensus for prophylaxis (50). However, for most other types of surgery, the incidence of thromboembolism and the need for prophylaxis have been well demonstrated. Specific to general surgery, in a meta-analysis of over 50 trials with a total of more than 4,000 patients, Clagett and Reisch (51) determined the overall rate of DVT

in control patients to be 16 to 30%. The more serious finding of proximal DVT, which is DVT proximal to the popliteal vein, was 7%; and the rate of fatal pulmonary embolism was 0.9%. In general surgery, prophylaxis through use of anticoagulants reduces the relative risk of DVT by up to 80%; compression devices offer similar risk reduction (2,3).

Orthopedic patients can also benefit greatly from DVT prophylaxis (2). Specific to elective joint replacement patients, the rate of postoperative DVTs has been measured at 40 to 80%. The rate of fatal PE in various studies is reported to be from 0.3 to 6% (16-18,41). Although the exact incidence or mortality is in dispute, there is general agreement on the usefulness of preventative measures, which again reduce the rate of DVT by up to 80% compared with nonprophylaxed patients (40).

Despite the well-known benefits of DVT prevention, several studies have shown that prophylaxis for thromboembolism is underutilized (52-56). Several possible reasons exist for surgical patients not receiving DVT prophylaxis, including concerns over bleeding, thrombocytopenia and the cost of prophylaxis. Fears of major bleeding in post operative patients treated with low dose unfractionated heparin or low molecular weight heparin are unfounded (25). There may be a slight increased incidence of wound hematomas with anticoagulation (26) which can be avoided through use of mechanical methods of DVT prophylaxis, such as SCDs. Heparin-induced thrombocytopenia (HIT) is uncommon; vascular thrombosis associated with HIT is even more rare (57). The economic benefits of DVT prophylaxis have been shown to far outweigh its costs (58,59).

One final reason that a physician may not order DVT prophylaxis is the subjective opinion that DVTs or PEs are not a problem in his or her individual practice, as overt

cases of thromboembolism are rarely encountered. The answer to such an objection is a statistical one, concerning the perception of low frequency events and individual versus group experience (60). If a surgeon does 100 major surgeries in a year and orders prophylaxis 90% of the time, and 1% of nonprophylaxed patients suffer a fatal PE, then that surgeon will see a fatal PE once every 10 years on average, and only a few times over the duration of his or her career. Therefore the impression arises that fatal PE is not a common problem, which leads to complacency over ordering prophylaxis. However, if all surgeons in a hospital perform several thousand major procedures a year and only 90% of these patients have prophylaxis, there may be 2 or 3 deaths per year from PE. Thus, although the individual surgeon will rarely see a fatality from PE, the aggregate data show the problem in its true magnitude. Appropriate prophylaxis can reduce the number of PEs by up to 80% and could therefore conceivably save several lives per year in a large surgical center.

Given that DVT prophylaxis in appropriately selected surgical patients is desirable and constitutes good medical practice, there are 3 reasons eligible patients may not receive this therapy. The first is an issue of lack of knowledge; some doctors may not be aware of the advantages conferred by prophylaxis and so do not order preventative measures. Incognizance can be ameliorated through physician education (61). A second possibility is that the physician orders prophylaxis, but there is a breakdown in the process of care, resulting in a nonprophylaxed patient. Berwick (62) has examined the problem of quality assurance and described the many stages where physician orders may go askew.

The final reason why prophylaxis may be missed is McDonald's observation that all physicians occasionally forget (63). Even the best trained clinicians have a measurable rate of omitting to do things that they know they should do. To quote, "...man is not perfectible. There are limits to man's capabilities as an information processor that assures the occurrence of random errors in his activities" (p.1351). This same insight is present in Leape's paper on Error in Medicine (64).

Attempts to Improve Rates of DVT Prophylaxis

The medical literature acknowledges the problem with shortcomings in the administration of DVT prophylaxis and promotes the benefit that may accrue from wider use of prevention. Elliott closed his review of pulmonary embolism with these words: "The consistent application of efficacious prophylactic methods to all patients at risk may be the greatest advance in the management of venous thromboembolism in the coming years" (2, p.72).

Few papers address the problem of increasing the use of DVT prophylaxis. Attempted methods to improve prophylaxis include local consensus conferences and frequent reinforcement to junior house staff, as well as manual reminder systems and feedback to physicians (65).

A Danish study looked at rates of DVT prophylaxis for surgery from 1981 to 1990. It found that the rate of prophylaxis increased from 50% to 68% over this interval. The authors speculate that the increase may be due to mandatory theoretical surgical education, in place in Denmark since 1987 (66).

A pair of British studies also looked at changing rates in DVT prophylaxis in elective surgery (53,67). The first study, in 1994, reported a prophylaxis rate of 85%. The authors then instituted a program which consisted of education of junior residents (who write most of the orders) and a preoperative checklist, used by the nursing staff. In the follow up study 1 year later, the rate of prophylaxis had increased to 97 %. It is important to note the limits of the study - only 77 patients were involved and there was no statistical analysis. No long-term follow up was done to measure attrition.

An American study compared 2 different methods of increasing DVT prophylaxis to a control group. The study measured the rate of DVT prophylaxis at 29% in 15 short stay hospitals in 1986. The hospitals were then divided into 3 groups. The control group had no interventions. The Continuing Medical Education (CME) group received several educational seminars on the importance of DVT prophylaxis. The Quality Assurance (QA) group received the same education as the CME group, plus individual surgeons were sent letters informing them of their personal rate of prophylaxis and how they compared to their peers. In 1989, the rate of DVT prophylaxis was measured again. The control group prophylaxis rate increased to 51%; the CME group increased to 49%; and the QA group increased to 55%. The authors concluded that even after extensive CME/QA interventions, prophylaxis for venous thromboembolism remained underutilized, and suggested that new approaches to changing clinical practice be developed (68).

The 3 studies cited above demonstrate that increasing DVT prophylaxis is not a simple matter. Education, manual reminders and physician feedback appear insufficient to increase and sustain the use of DVT prophylaxis. Is there a better strategy? Leape's

paper on Error in Medicine suggests standardization and reduction of reliance on memory (64). In his oft-quoted seminal 1976 paper, McDonald is even more specific when he concludes "...though the individual physician is not perfectible, the system of care is, and...the computer will play a major part in the perfection of future care systems" (63, p.1355). Like the proverbial elephant, the computer never forgets. Despite the potential of this tool, a review of the literature through a Medline search failed to find any studies which used computer generated reminders to increase DVT prophylaxis.

Computerized Reminders

A powerful clinical application in medical informatics is the use of computer generated reminders and alerts. Rind et al. defined a reminder as "a communication that is sent to a clinician around the time of patient contact," whereas an alert is a communication "...sent to a clinician as soon as the conditions that prompt the generation of the alert are known to have occurred" (69, p.122). Numerous studies have demonstrated the efficacy of computer reminder and alert systems, for both outpatient and inpatient use (70-84). A recent meta-analysis by Shea et al. of 16 randomized controlled trials showed the effectiveness of computer-based clinical reminder systems for preventive care in the ambulatory setting (85).

For over 20 years, the LDS Hospital in Salt Lake City has had a clinical computing system known by the acronym HELP (Health Evaluation through Logical Processing) (86-91). The HELP system has successfully integrated information management and clinical medicine, including several applications of alerts and reminders. These programs have been of use in preventing adverse drug effects and administering

preoperative antibiotics. The authors of these projects have been able to show changes in process outcomes, clinical outcomes and substantial cost savings (92-96).

One innovative project at LDS Hospital has been the antibiotic reminder program for surgical patients. Introduced over a decade ago, the antibiotic reminder program automatically screened surgical patients and flagged those who were to receive perioperative antibiotics. Originally a sticker was placed on the patient's chart; the sticker was soon superseded by a printed reminder on the operating room (OR) schedule. With this computerized reminder in place, the rate of perioperative antibiotic use in appropriate procedures increased from 40% in 1988 to 99.1% in 1994. Postoperative wound infections decreased from 2% to 0.4% during the same period (92,93,97-99).

Computers can generate reminders and alerts in 2 different ways. In event-driven programs, the user inputs some or all of the necessary data, and then receives consultative output. For example, in the diagnostic program Iliad, the user enters the patient's symptoms, physical findings and laboratory results. The program responds with a list of differential diagnoses and relative probabilities. If the user enters more information, the list and probabilities may change. The 'event' is the user entering data (100).

In data-driven programs, the user remains passive and is prompted by the system whenever a set of criteria is met. The components of a data-driven system usually include the clinical data, an expert system to monitor the database, and a knowledge base with rules of logic that trigger the reminder (101). The reminder itself may be a message for the physician during the next sign-on to the hospital's information system, a message on the physician's pager, or a note placed in the chart by nursing or clerical staff. An example of a data-driven system is the antibiotic reminder at LDS Hospital, discussed

above. The primary advantage of the data-driven method is that the reminders are generated automatically, satisfying Leape's criteria of standardization and reduced reliance on memory.

Outline of Remainder of Thesis

The remainder of the thesis will describe in detail the Methods and Results of a study conducted at LDS Hospital. The study measured the baseline rate of DVT prophylaxis at the hospital and then remeasured the rate after implementation of a computerized reminder. The Methods and Results sections are followed by a Discussion section which addresses the Quality Improvement (QI) process, physician guidelines, cost issues and limitations of the study. After the Summary and Conclusions, there is a list of appendices followed by references cited in the text.

II. METHODS

List of Hypotheses

The purpose of the study was to develop a computerized reminder system to ensure that appropriate preoperative DVT prophylaxis was ordered for eligible patients.

The hypotheses were as follows:

H_O (null hypothesis) - A computerized reminder system will not affect the rate of DVT prophylaxis in surgical patients.

H_1 (alternate hypothesis) - A computerized reminder system will affect the rate of DVT prophylaxis in surgical patients.

Setting

The study was carried out at LDS Hospital in Salt Lake City, Utah. LDS Hospital is a facility of Intermountain Health Care (IHC), a health maintenance organization which covers approximately 750,000 people in 3 states. LDS Hospital is licensed for 520 beds and is an academic teaching center affiliated with the University of Utah. Surgical departments and divisions include general surgery, orthopedic surgery, gynecological surgery, urological surgery, cardiovascular surgery, thoracic surgery, plastic surgery and neurological surgery. There is no elective pediatric surgery at the hospital. The surgeons at LDS Hospital perform over 15,000 cases a year.

The majority of the preliminary work for the study was done July to October 1997; data gathering took place November 1997 to January 1998; analysis and write up were done February to April 1998.

Institutional Review Board (IRB) approval for the study was obtained from both LDS Hospital and the University of Utah and was filed with the Graduate Records Office at the University of Utah.

Study Design

The study was a pre- and postmeasurement of compliance in a study group compared to historic controls. The study methodology was based on the quality improvement (QI) work of Berwick (62,102-105) and Williamson (106-109), as well as the steps in the continuous quality improvement (CQI) approach as practiced by Kuperman, James, Jacobsen and Gardner at LDS Hospital (110). The major steps in the study were to evaluate the baseline rate of DVT prophylaxis, assess any Achievable Benefit Not Achieved (ABNA), plan for a change in work patterns, implement the change, and then reevaluate.

The concept of ABNA deserves further comment. ABNA is the difference between the results achieved with the current standard of practice, and the best results that are possible to achieve under real circumstances. For example, clinical outcome after myocardial infarction is known to be related to the time between patient presentation in the emergency department and the time of treatment with thrombolytics (111,112). If the best emergency wards in the country take an average of 10 minutes to administer thrombolytics to heart attack patients, and Hospital XYZ takes 11 minutes for the same

task, not much ABNA exists. If, however, Hospital XYZ takes 45 minutes to administer thrombolytics, then considerable room for improvement (ABNA) exists.

Congruent to the concept of ABNA is the Minimal (or Maximum) Acceptable Standard (MAS). The MAS is the specific goal set to eliminate ABNA. For example, a surgical department may have a postoperative wound dehiscence rate of 5% for major abdominal procedures. The surgeons in the department know that the average rate of dehiscence is 3%. They set a goal for their department of 2.5% - this rate becomes their MAS for wound dehiscence. If they succeed in achieving their goal, they would have eliminated the ABNA.

Description of Patient Population

All patients scheduled for a procedure which qualified for DVT prophylaxis, as determined by the participating surgeons, were included in the study. There were no pediatric patients (age less than 16) in the study. Both elective and emergency cases were included in the study. Consent for participation in the study was not obtained from individual patients as DVT prophylaxis is considered a routine part of surgical care and the patients were not exposed to new drugs or devices.

Description of Hospital Staff Involved

Letters announcing the project were sent out to all divisions of surgery by Dr. Greg Elliott, a pulmonary physician at LDS Hospital who was well known for his work with venous thromboembolism. Dr. Elliott was an advisor to the author and a member of the graduate committee that judged the thesis. A copy of the text in the letter is in

Appendix A. The divisions of general surgery, orthopedic surgery, gynecological surgery and urologic surgery agreed to join the study. The divisions of plastic surgery, thoracic surgery and neurologic surgery did not reply or declined participation.

Hospital staff other than surgeons were also involved in the study. The nurses in the short stay (same-day admission) unit, the orthopedic unit, and the OR played an important role in the study, as described below. In addition, the surgical staff who assemble the case carts participated in the study. One of the hospital's programmers, Kyle Johnson, wrote one program for the study and helped debug another. Numerous individuals from the Department of Medical Informatics gave advice and direction when needed.

Determining Baseline DVT Prophylaxis Rates

The initial step in the study was to determine the baseline rate of DVT prophylaxis and decide if there was any room for improvement, or ABNA. The baseline rate was expressed as the ratio of the number patients receiving prophylaxis over the number of patients requiring prophylaxis. If the baseline rate of DVT prophylaxis approached 100%, then it would not be necessary to embark on an effort to increase the rate.

Logically, it may be assumed that the most straightforward method to measure the baseline rate of DVT prophylaxis in historic controls would be to directly query the patient database at LDS Hospital. However, different types of data are stored in different locations using different coding systems. The process used to measure the rate of prophylaxis in historic controls is explained in this section.

Patient data at the LDS Hospital are stored on the HELP (Health Evaluation through Logical Processing) system as PTXT (Pointer-to-Text) codes. The HELP system contains 3 patient databases. The current database contains information on inpatients from time of admission up to 10 days postdischarge. The short-term archive has information on patients from time of discharge to 6 months postdischarge. The long-term archive is the repository of all patient information back to 1983.

Information germane to this study stored in the HELP system would include the primary surgical procedure, any medications given and the use of SCDs. In the hierarchical PTXT coding system, the first digit is the data class. Scheduled procedures are data class 38. All scheduled procedures begin with the number 38, and all patients scheduled for surgery will have a PTXT code beginning with 38 in their electronic clinical record. The third digit is the field code, which will vary by department of surgery. For example, orthopedic surgery is field code 18. A star represents a wild card character. Thus, the PTXT code 38.*.18.*.* indicates a scheduled orthopedic procedure. The specific procedure is defined by the content in place of the wild cards. For example, a scheduled total hip replacement is coded in PTXT as 38.1.18.1.78. Once the procedure has been completed, the data class is changed to 24, i.e., a completed hip replacement is coded as 24.1.18.1.78. The third and fifth digits alone may also be used to represent the procedure; thus an alternate of writing the PTXT code for a hip replacement is 18.78.

PTXT codes also exist for prescribed drugs. However, for each medication it was necessary to refine the list of PTXT codes. For example, when searching for PTXT codes under 'heparin' in the cross reference feature of HELP, over 40 different codes were matched. Some of these codes were for heparin-coated devices, or a minuscule dosage of

heparin to 'hep-lock' an intravenous (IV) site, a standard nursing practice to prevent a blood clot from blocking the line. These uses of heparin obviously do not constitute perioperative venous thromboembolic prophylaxis and their inclusion in the study would be misleading. Only 2 heparin PTXT codes were included in the study as these the 2 forms of heparin are used for DVT prophylaxis - heparin injection subcutaneous (8.1.8.2.3.10.0.0) and low molecular weight heparin (8.1.8.2.3.152.0.0). Coumadin, which is used for DVT prophylaxis in total joint replacement patients, has the PTXT code 8.1.8.2.1.1.0.0 and was also included in the study.

Similar to the PTXT procedure codes, the data class of the PTXT code for a medication changes once the medication has been taken by the patient from data class 8 to data class 48. For example, when a physician prescribes coumadin, the PTXT code for the prescribed medication in the HELP system was 8.1.8.2.1.1.0.0. Once the patient has taken coumadin, the PTXT code became 48.1.8.2.1.1.0.0.

Sequential compression devices (SCDs) and Plexipulse boots (a type of SCD) are coded in the same manner. The PTXT codes used in the study to determine DVT prophylaxis were SCD leg wrap (46.1.11.2.14.105.0.0), SCD foot wrap (46.1.11.2.14.110.0.0) and Plexipulse boots (112.1.33.3.50.30.35.0).

Each PTXT code for medications and mechanical devices has a corresponding charge code listed in the AS400 computer, which the hospital uses for financial and billing purposes. When a PTXT code for a medication or other device is entered into the HELP system, a charge code for the item is captured in the AS400 financial system. The forms of DVT prophylaxis along with their corresponding PTXT codes and charge codes

are shown in Table 1. The relationship between the HELP system and the AS400 system is shown in Figure 1.

The patient's electronic record consists of clinical information, including surgical procedures and medications, coded as PTXT codes. The ideal method of measuring the baseline rate of DVT prophylaxis would be to query the HELP long-term archive for PTXT codes for surgical procedures where prophylaxis is indicated, and then search those patient records for the PTXT codes listed in the table above. However, information in the financial system (the AS400) does not always form part of the electronic clinical record. For example, SCDs which are used only at the time of surgery are not coded into the electronic clinical record, although later on they may be coded into the record if the patient is admitted to a surgical unit with SCDs in place. A search of the HELP long-term archive would not reveal all cases where SCDs were used for short stay procedures.

Fortunately, another method existed to measure baseline DVT prophylaxis. Data from both the HELP system (procedure codes) and the AS400 (charge codes for medications and SCDs) are archived in IHC's Enterprise Data Warehouse (EDW) in an Oracle relational database. The procedure codes and charge codes are stored in 2 different tables - the Patient Encounter Summary table and the Hospital Encounter Transaction

Table 1. Forms of DVT prophylaxis with their PTXT codes and charge codes.

Item	PTXT code	Charge code
heparin injection	8.1.8.2.3.10.0.0	7642762
LMWH	8.1.8.2.3.152.0.0	7636418
coumadin	8.1.8.2.1.1.0.0	7671449
SCD leg wrap	46.1.11.2.14.105.0.0	784207
SCD foot wrap	46.1.11.2.14.110.0.0	788109
Plexipulse boots	112.1.33.3.50.30.35.0	788752

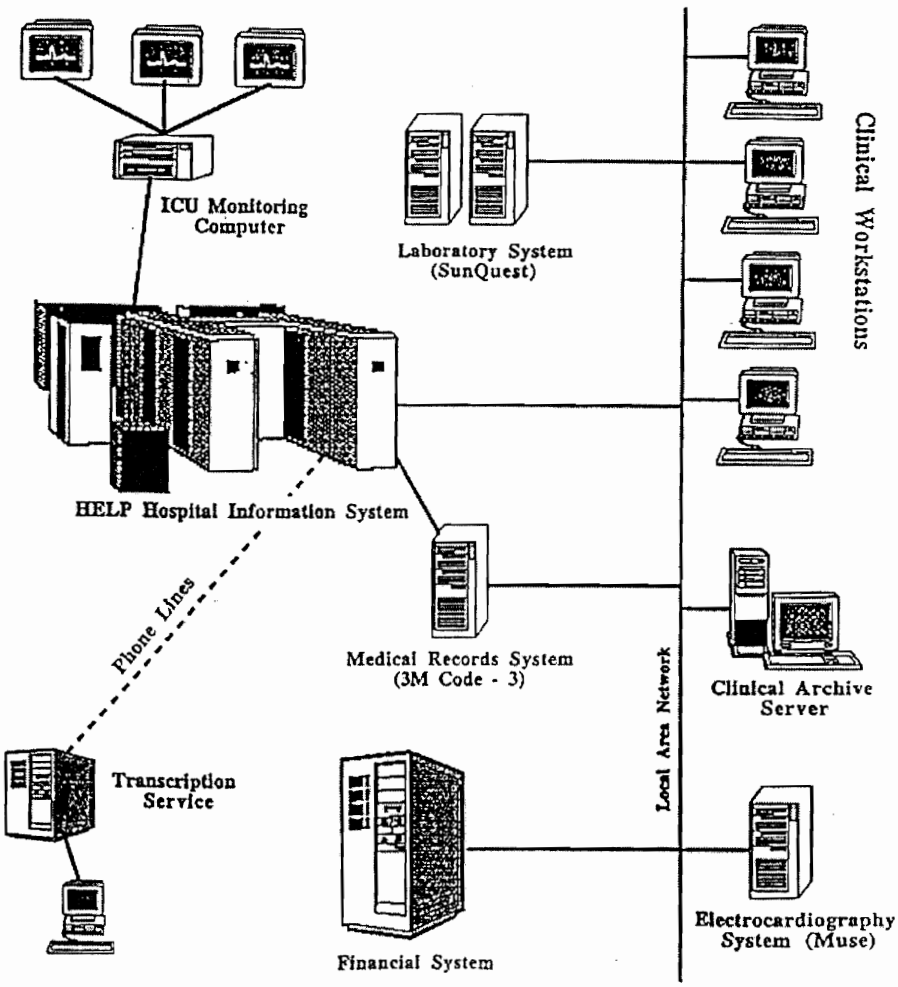

Figure 1. Relationship between the HELP system and other hospital systems. The AS400 financial system is shown in the diagram. PTXT codes carrying a financial charge that are entered into the HELP system will also appear in the AS400 as charge codes. However, a charge code entered directly into the AS400 does not necessarily appear as a PTXT code in the HELP system.

table. The 2 tables have a common field in the Encounter ID. By using Standard Query Language (SQL) statements, it was possible to query the EDW database for patients who had specified procedures, and determine how many of those patients had received DVT prophylaxis in terms of an anticoagulant (heparin, low molecular weight heparin, or coumadin) or SCDs by checking the charge codes.

Procedure codes in the EDW are stored as ICD9 codes, not PTXT codes. Each PTXT procedure code has a corresponding code in the International Classification of Disease, 9th edition (ICD9), Volume 3. For example, a total hip replacement has a PTXT code of 24.1.18.1.78 (or 18.78); the equivalent ICD9 code is 81.51. The 2 coding systems have been mapped to each other in the cross reference feature of the HELP system.

To restate: the PTXT codes are stored in the HELP patient databases. The ICD9 codes for the same procedures are not stored in HELP; rather, they are stored in the Oracle database of IHC's Enterprise Data Warehouse. Conversions of codes from the PTXT format to the ICD9 format occurs as data are moved from the HELP and AS400 systems to the Casemix files stored in the EDW. The search of the EDW to measure baseline prophylaxis rates used ICD9 procedure codes, not PTXT codes.

An initial list of procedures which qualify for DVT prophylaxis was composed by the author. The list contained common procedures for which DVT prophylaxis was widely accepted. (The list was later expanded after meeting with various divisions of the Department of Surgery at LDS Hospital - see below.) The full list is contained in Appendix B. The list included major abdominal surgery, breast cancer surgery, endocrine

surgery, total joint replacement surgery, major orthopedic trauma, hysterectomies, nephrectomies and prostatectomies.

Of note, a procedure may have more than one ICD9 code. For example, there are 3 ICD9 codes for esophagectomy, as there are 3 different surgical techniques for removing the esophagus. Similarly, there are 5 ICD9 codes for gastrectomy, depending on which part of the stomach is removed. As these codes represent variations of the same procedure, they have been grouped together under a single procedure name when appropriate.

Using the ICD9 procedure codes and the charge codes for anticoagulants and SCDs, an initial query of the EDW was done for the year 1996. An example of a SQL statement used to query the database is given in Figure 2. The first query determined how

```
select distinct
      p.encntr_id, p.hsptl, p.prcdr1, p.dschrg_month, p.dschrg_yr
      from cm.pt_encntr_smry p, ar.trnsctns t
      where p.encntr_id = t.encntr_id
      and p.hsptl = 128
      and p.dschrg_yr = 1996
      and p.prcdr1 = '8151'
      order by p.encntr_id;

select distinct
       p.encntr_id, p.hsptl, p.prcdr1, p.dschrg_yr
       from cm.pt_encntr_smry p, ar.trnsctns t
       where p.encntr_id = t.encntr_id
       and p.hsptl = 128
       and p.dschrg_yr = 1996
       and t.chrg_cd in (7642762, 7671449, 7636418, 784207, 788109,788752)
       and p.prcdr1 = '8151'
       order by p.encntr_id;
```

Figure 2. Standard Query Language (SQL) statements. These SQL statements were used to query the EDW database to measure the baseline rate of DVT prophylaxis in the historic controls.

many cases of a particular procedure were done at LDS Hospital in 1996. In the example below, the procedure is ICD9 code 81.51, total hip replacement. The second query determined how many of these cases received DVT prophylaxis. The rate of DVT prophylaxis is the result from the second query (number of prophylaxed cases) over the result of the first query (number of cases requiring prophylaxis).

Results from the query are shown in the table in Appendix B. In summary, DVT prophylaxis rates were determined for 40 different procedures. The rate of prophylaxis for some procedures was perfect, including 30 out of 30 cases of pancreatic surgery. For other procedures, it was near perfect, such as 189 out of 193 hip replacement surgeries, a rate of 98%. Any attempt to prove statistical significance in improving such a high rate would require large numbers over several years and likely would not have a measurable clinical impact.

There were several procedures for which prophylaxis was well below 100%. For example, 494 of 562 (88%) of laparoscopic cholecystectomy procedures had prophylaxis, leaving 68 patients (12% of all laparoscopic cholecystectomies) uncovered. The issue here is not one of disagreement over whether prophylaxis was indicated, as all general surgeons would later agree that all 'lap choles' should be covered. As another example, prophylaxis for thyroid and parathyroid surgery was only 53% (46 of 86 cases). Overall, for the 4 divisions that participated in the study, the 1996 DVT prophylaxis rate for the selected procedures was 73.3% (2,474 of 3,375 cases).

The rate of 73.3% suggests that there is considerable room for improvement, or Achievable Benefit Not Achieved (ABNA). The results of this initial query were later presented to the 4 participating divisions of surgery, along with information from the

International Cooperative Pulmonary Embolism Registry (ICOPER) study, previously conducted at LDS Hospital.

Data from the ICOPER Study

The unfortunate sequalae of deep vein thrombosis include pulmonary embolism. PE can have a late presentation, occurring several weeks or months after the operation (21). By that time the patient is usually home, which for IHC patients may be in another city or even another state. However, at least some of the patients will be readmitted to the LDS Hospital, and thus although the exact magnitude of PE cannot be determined, some cases can be detected. In 1995 and 1996, the LDS Hospital participated in the ICOPER study (113), a study designed to quantify and qualify the disease of pulmonary embolism. The ICOPER data was reviewed to see how often a postsurgical PE (defined as PE within 2 months of surgery) presented to LDS Hospital, with the rationale that if no cases of PE occurred, then there would be no need to increase the rate of DVT prophylaxis.

The LDS ICOPER data showed that in a 18-month period, 27 patients presented to LDS Hospital with postoperative PE. Nineteen of these patients had not received any form of DVT prophylaxis. Otherwise stated, 70% of postsurgical cases of pulmonary embolism occurred in patients without prophylaxis and were potentially preventable. A summary of the results of the ICOPER study is presented in Appendix C.

Developing Consensus on Procedures Requiring DVT Prophylaxis

The next step was to meet with the participating divisions of surgery at LDS Hospital to develop a more specific list of procedures to be covered by DVT prophylaxis. The author met with each division separately, reviewed the problems of deep vein thrombosis and pulmonary embolism, and presented the findings from the initial database search and the ICOPER study.

Recommendations for prophylaxis as per criteria of the American College of Chest Physicians (ACCP) were accepted as a guideline to be used in developing the list of procedures. The ACCP recommendations were developed after a consensus conference in 1995 (2) and are summarized in Appendix D. The key recommendation is that any surgery lasting greater than 30 minutes should have DVT prophylaxis.

Surgical procedure codes form part of the PTXT codes in the HELP system. The procedure codes were originally developed for the benefit of the surgical staff who assemble the case carts, which are the collections of instruments and materials necessary to do the specified surgery. The first PTXT procedure list was organized alphabetically by procedure. For example, in general surgery all PTXT codes start with 14. The codes 14.1, 14.2 and 14.3 represented abdominal perineal resection, ampullary sphincteroplasty and anal fistula. The list continued alphabetically to 14.77, which was a ventral hernia repair. The list has been modified over the years and new procedures were added to the end of the list as they appeared, without trying to retain the alphabetical nature of the list. The most recently coded procedure is 14.192, laparoscopic colectomy.

One or two physician volunteers from each division then met with the author to further refine the list of procedures for prophylaxis. For each division, the list of

procedures was reviewed, discussed and modified by other members of the division until consensus was obtained. In the case of a disagreement over a particular procedure, the procedure was not included in the list and any surgeons wishing prophylaxis for those cases could order it at their own discretion. A potential bias was thereby avoided through elimination of the situation where surgeons may not order prophylaxis if they disagreed with the need for it in a particular procedure. Reaching consensus was most arduous in the division of orthopedic surgery, where many procedures were removed from the preliminary list, in spite of their satisfying ACCP criteria.

The final approved list of procedures for DVT prophylaxis is presented as Appendix E. Procedures under a general anesthetic which lasted more than 30 minutes were usually included in the list of procedures to receive DVT prophylaxis. For example, a cholecystectomy will almost always last longer than half an hour and was listed for prophylaxis. Open appendectomies usually take less than 30 minutes and were not included on the list.

Intradivision variation existed in the types procedures selected for prophylaxis. For example, the general surgeons decided to cover all of their laparoscopic cases, even laparoscopic appendectomies which often last less than 30 minutes. Their physiologic rational was that increased intraabdominal pressure from the pneumoperitoneum may predispose the patient towards thromboembolism. By contrast, the gynecologic surgeons decided to cover only the laparoscopic cases which usually took greater than 30 minutes. They excluded from the study some of their more common procedures, such as diagnostic laparoscopy and laparoscopic tubal ligation, which ordinarily take less than half an hour to complete.

Several exceptions were made to the 30 minute rule by the Division of Orthopedic Surgery. Shoulder repairs and spinal surgeries may last several hours, yet the division could not reach consensus on whether or not these cases should receive DVT prophylaxis. These procedures were not included in the study and the decision to use prophylaxis was left to the individual surgeon.

For the method of DVT prophylaxis, the orthopedic surgeons decided that joint replacement patients should have anticoagulation in the form of heparin, LMWH, or coumadin. The surgeons from the divisions of general, gynecologic and urologic surgery decided that their patients would receive compression stockings for most procedures. Individual surgeons were free to vary from the consensus, including the option of both forms of prophylaxis for high risk patients, or canceling prophylaxis altogether if they thought it not appropriate for the case.

Refining the Database Search

A second database search of IHC's Enterprise Data Warehouse was then done, this time specific for the procedures listed by the surgeons, with the time frame limited to 3 months (November 1996 to January 1997). The period of 3 months was selected to allow a sufficient number of cases to show statistical significance at the level of groups of similar procedures where current rates of prophylaxis fell short (see Calculation of Sample Size below). The same methods and SQL statements were used to search the EDW for the 3-month period as were used in the initial queries for the year 1996. The results of the second database search formed the baseline prophylaxis rate in the historic controls, to which the study group was compared.

The dates of the second database search were selected to coincide with the dates of data collection for the study group (November 1997 to January 1998) to rule out any bias due to seasonal variation. One concern was that the collection dates for the study group included the winter holiday season; a comparison with summer or fall months may not be equitable, as the number and types of surgeries done may vary by season. For example, few patients want elective major surgery around Christmas or New Year's Day. Therefore, the same months of the year were used to measure the DVT prophylaxis rates in both the historic controls and the study group in an attempt to have similar numbers and types of cases.

Of note, not all of the procedures listed by the surgeons had cases in the database, as shown in Table 2.

The reason for the discrepancy is twofold. First, the list of procedures for DVT prophylaxis contained a number of uncommon procedures which may not have been done during the period covered by the query. For example, the general surgeons listed spleno-renal shunt as a procedure requiring DVT prophylaxis, yet only a few of these rare procedures are done each year at LDS Hospital.

Table 2. Procedures selected for DVT prophylaxis and procedures found in the EDW database.

Division	Procedures listed for DVT prophylaxis	Procedures found in EDW database
General Surgery	93	33
Orthopedic Surgery	36	12
Gyne Surgery	60	15
Urological Surgery	25	11

The second reason is that the PTXT coding system will often give several different codes to what is essentially the same procedure. The PTXT surgical procedure codes were originally developed to assist in case cart preparations. Case carts contain all of the instruments and materials necessary to perform the procedure. The same procedure may be done with different instruments, according to surgeon preference, and thus a procedure may have more than 1 PTXT code but only 1 corresponding ICD9 code. For example, there are 10 PTXT codes for total abdominal hysterectomy, yet only 1 ICD9 code for total abdominal hysterectomy. Two PTXT codes exist for ankle fusion; again, there is only 1 corresponding ICD9 code. Over time, surgeons come to prefer one case cart set up over another, and although some PTXT procedure code still exist in the HELP system, they may no longer be used for any cases.

For the rest of the thesis, the redundant codes for identical procedures and codes for procedures which had no cases in the database were not listed in the results.

The full results of this second database search, which formed the DVT prophylaxis rates in the historic controls, are presented in Appendix F. In summary, the search yielded an initial baseline prophylaxis rate of 74.1% (757 of 1021 cases). The database search was followed by a manual chart audit, as a concern was how accurately the electronic record captured patient data. Both false positives (prophylaxis electronically charted but not given) and false negatives (prophylaxis given but not electronically charted) could exist.

False positives are errors of commission where the nursing staff charts a medication or device into the HELP system that patient did not receive. Approximately 30 charts were audited for a variety of procedures where prophylaxis was electronically

charted; no false positives were found. The false positive rate for the control group was considered to be effectively zero.

False negatives are errors of omission and can exist if the patient received a medication or used a device and the fact was not charted in the computer. A medication or device may not have been electronically charted but may be manually documented in the paper chart. Therefore, in order to determine if any false negatives existed, a manual chart review was done for all 264 patient charts which did not have DVT prophylaxis recorded in the EDW database. The results of the manual chart review are summarized in Figure 3.

The manual chart review showed that for the 264 charts with no apparent DVT prophylaxis, 6 charts were not located or were unavailable for review. Thirty-six cases had the wrong facility code as they had been done at the Surgicenter, which is another surgical facility across the street from LDS Hospital. Most of these cases (25/36) were of a single procedure (panniculectomy). Surgicenter cases were not part of the study; therefore these 36 cases were excluded from the study.

Twenty-two cases had been coded as myomectomies. Because of an uncertainty over what constituted a myomectomy versus a biopsy, this procedure was dropped from the study. Sixteen cases had the wrong primary procedure code. When the primary procedure code was corrected to reflect the procedure that had actually been done, 7 cases fell under procedures listed for DVT prophylaxis and so were retained in the study. For example, a case which had been coded as a pelvic lymphadenectomy was actually a mastectomy with axillery node dissection. Two cases coded as total hip replacements were repairs of hip fractures.

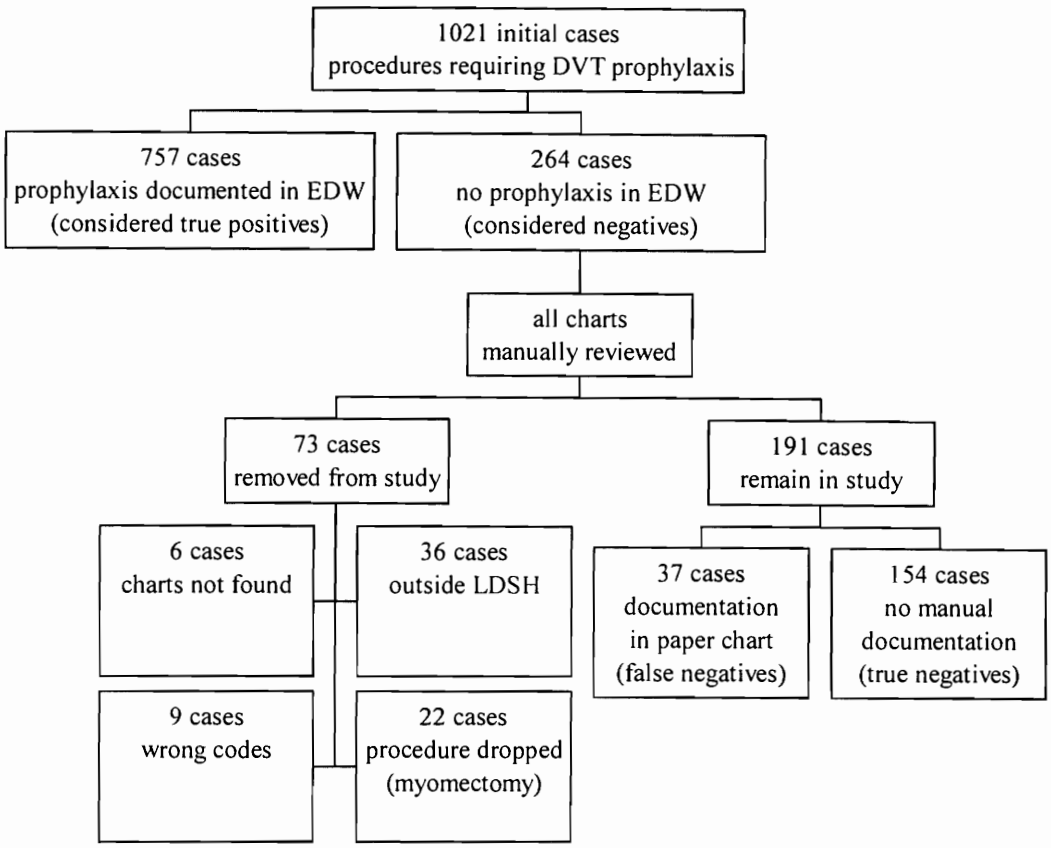

Figure 3. Flowchart showing change in baseline rate of prophylaxis. The initial baseline rate of prophylaxis of 74.1% (757 of 1021 cases) changed to 83.8% (794 of 948 cases) after manual chart review.

For the remaining 9 miscoded cases, 3 cases coded as hip fractures were actually fractures of the clavicle. A collagen injection of the urethra was miscoded as a urethral suspension. Three times a cesium injection had been incorrectly coded as an iliac node dissection. On one occasion a patient was readmitted shortly after discharge and given the same primary procedure code as the previous admission, even though no procedure was done during the second admission. A percutaneous endoscopic gastostomy (PEG)

procedure was miscoded as a bowel resection. All 9 miscoded cases were eliminated from the control group.

After the 73 cases were eliminated, 191 apparently negative cases remained in the control group. Review of these charts showed that 37 had some form of DVT prophylaxis recorded in the paper chart, for a false negative rate of 19%. Of the 37 cases which were false negatives, over half fell into just 2 procedures - laparoscopic appendectomy and laparoscopic cholecystectomy. These 2 procedures are often done as emergency cases and utilize SCDs for DVT prophylaxis. Each case should have a new SCD machine and leg wrappings; it is possible that late at night or on weekends some of the machines are reused and not charged to the second patient. No financial charge, and therefore no computer record of the SCDs, would exist, but the handwritten OR record documented the presence of the SCDs. The remaining false negatives were scattered throughout a number of procedures. For example, of the 11 thyroid cases thought not to have DVT prophylaxis, 2 cases had SCDs manually documented in the OR chart.

In summary, of the original 1021 cases in the historic controls, 757 cases were considered true positives. The 264 cases with no DVT prophylaxis recorded in the EDW were all manually reviewed. Seventy-three cases were dropped from the study for various reasons, listed above. Of the remaining 191 cases, 37 were false negatives. The rate of DVT prophylaxis in the historic controls was therefore 794 of 948 cases, or 83.8%.

For the division of general surgery, the baseline rate of DVT prophylaxis was 86.0% (416 of 484 procedures), orthopedic surgery 87.7% (171/195), gynecologic surgery 74.1% (152/205), and urological surgery 85.9% (55/64). The breakdown by individual procedure is given in Appendix F.

The baseline rate of 83.8% DVT prophylaxis in the historic controls from November 1996 to January 1997 was higher than the rate of 73.3% which was measured for the year 1996 at LDS Hospital. Two reasons explain the difference in rates. In the query for the year of 1996, several procedures with low prophylaxis rates were included which were not in the second query. For example, the initial query included the procedures of lower limb amputations (prophylaxis rate of 63%) and TURPs (prophylaxis rate of 11%). These procedures were not included in the consensus for procedures requiring DVT prophylaxis and were excluded from the second query. The second reason is that the negative cases in the 1996 query did not have a manual chart review to determine the rate of false negatives, as was done for the November 1996 to January 1997 query.

Calculation of Sample Size

Sample size calculations are for the chi square test of a pre- and poststudy change in compliance. The arcsine transformation method was used to calculate sample size necessary to demonstrate statistical significance for a 1-tailed alpha of .05, power of 80 (114).

The sample size n depends on 2 factors: the known starting rate and the desired concluding rate. Table 3 for a final rate of 90% and Table 4 for a final rate of 80% are shown below. If, for example, the goal were to demonstrate statistical significance in a change from a rate of 30% to a rate of 90% (the first row of Table 3), then n = 10 was needed. If, however, the goal were to change from 70% to 80% (the final row of Table 4), then n = 300 was required to demonstrate statistical significance.

Table 3. Sample size n required to demonstrate statistical significance when increasing a proportion from X to 90%.

X	rho Px	rho P90	h (delta rho)	n
30%	1.159	2.498	1.339	10
50%	1.571	2.498	0.927	15
60%	1.772	2.498	0.726	25
70%	1.982	2.498	0.516	50
80%	2.214	2.498	0.284	140
85%	2.346	2.498	0.152	>1000

Table 4. Sample size n required to demonstrate statistical significance when increasing a proportion from X to 80%.

X	rho Px	rho P80	h (delta rho)	n
20%	0.927	2.214	1.287	10
30%	1.159	2.214	1.055	11
60%	1.571	2.214	0.643	30
60%	1.772	2.214	0.437	75
70%	1.982	2.214	0.232	300

Analysis for statistical significance between the control and study groups was carried out at 4 levels - the individual procedure, groups of similar procedures within a division, between divisions, and all cases combined. The levels of analysis are shown in Figure 4.

With the sample size varying according to the rates of pre- and poststudy compliance, the duration of the study depended on the level at which significance would be demonstrated. For some individual procedures, few cases are done and considerable time would be necessary to accumulate the numbers needed to establish statistical significance. For example, in all of 1996 there were only 23 simple mastectomies at LDS Hospital, of which 12 received DVT prophylaxis, for a rate of 52%. To increase the rate

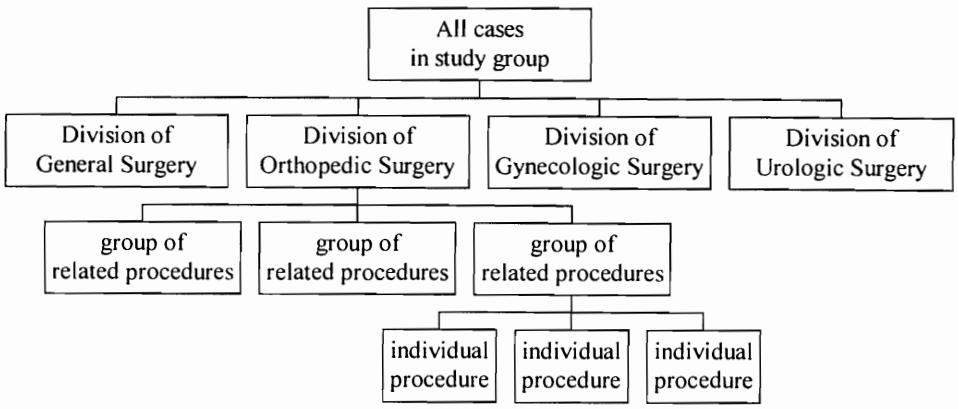

Figure 4. Flowchart of levels of statistical analysis. For simplicity of presentation, only 1 Division and group are broken down into their components.

to 80%, approximately 30 subjects would be needed to demonstrate statistical significance. Given the number of mastectomies performed at LDS Hospital, such a study would take over a year. If the goal was to increase the rate to 90%, then only 15 subjects would be needed and the study could be done in 6 months' time. However, if simple mastectomies (n = 23, rate of 52%) are combined with modified radical mastectomies (n = 82, rate of 65%), then the resultant category of 'breast surgery' would have n = 105, rate of 60%. To increase this rate to 80%, 75 cases would be needed to demonstrate statistical significance, which would take 9 months. However, if the rate of DVT prophylaxis was increased to 90%, then only 25 subjects would be needed to demonstrate significance, a number which could be accumulated over 3 months.

By combining individual procedures into groups of similar procedures (see Figure 4) and setting a Minimal Acceptable Standard (MAS) of 90% compliance, it was determined that 3 months of cases would provide sufficient numbers to demonstrate a statistically significant difference in rates of compliance for most groups of similar procedures, such as in the example above of joining different types of breast surgeries into a single group. Given the limited number of cases expected to accumulate for any 1 individual procedure, statistical significance at the level of individual procedures was not expected, especially for procedures with relatively low numbers of cases or where the rate of prophylaxis was already close to the MAS of 90%.

The Computerized Reminder

The next step in the study was to place a computerized reminder on the operating room schedule, which was generated through the HELP system (85). When a surgeon had a case, he or she requested OR time through the surgical booking office. At that point, the case existed as text only, e.g., 'repair of epigastric hernia'. A PTXT procedure code was then assigned by the surgical staff who assembled the case carts; the code is assigned at 10:00 am the day prior to surgery. The PTXT procedure code for epigastric hernia is 14.77 and once assigned forms part of the electronic data in the OR schedule, although it is not printed out in the paper version. The PTXT procedure code also becomes part of the patient's clinical electronic record.

Case carts contain all of the instruments and materials necessary to perform the procedure. For an epigastric hernia repair, a case cart will contain scalpels, retractors, sutures, etc. SCDs are not sent to the OR with the case cart unless requested.

The printed OR schedule was modified so that the letters **DVT** appeared next to the patient's name if that patient had a procedure scheduled which fell into the list of operations approved of by the participating divisions of surgery. An example of the modified OR schedule is shown in Appendix F. The second column from the left contains the DVT reminder. The program for the DVT reminder was written in Tandem Application Language (TAL) by Kyle Johnson, a programmer at LDS Hospital. The program ran 3 times per day via a time drive mechanism at 07:00, 11:00 and 15:00.

Figure 5 illustrates the relationships between the OR schedule, the patient's integrated clinical record, the knowledge base, the time driver, and the computerized reminder. When the surgical staff turn a surgeon's request for a case into a PTXT

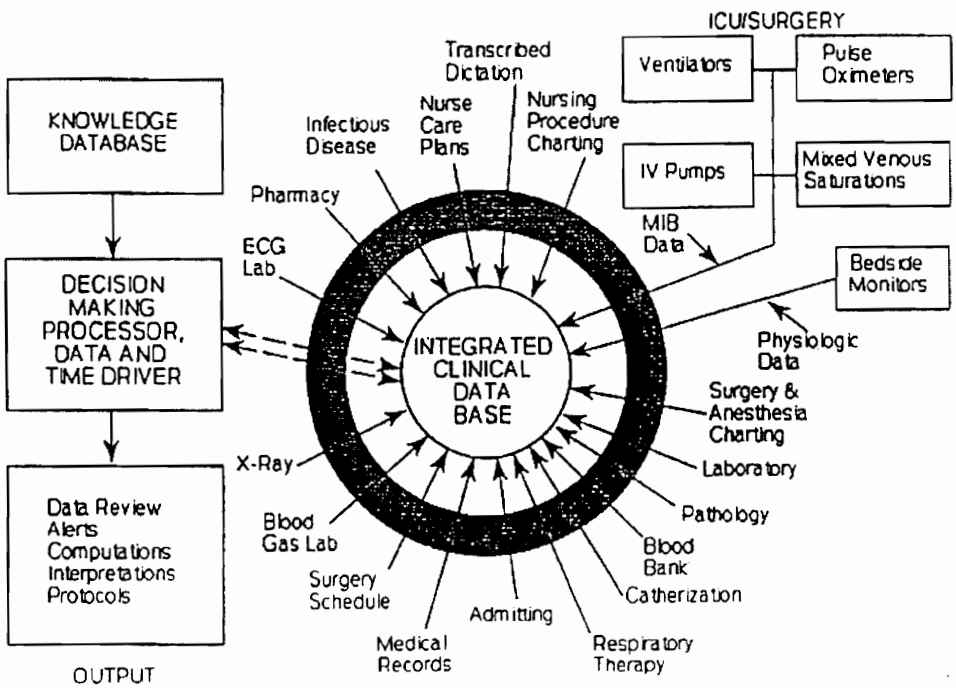

Figure 5. Schematic drawing of the HELP system. Information from numerous sources, including the surgery schedule, is combined into a central database. The dark circle represents the data drive capability of the system (115).

procedure code, the PTXT code becomes part of the surgery schedule and the patient's electronic clinical record. Three times a day the time drive mechanism searches the integrated clinical database on a subset of patients scheduled for surgery, checking for PTXT procedure codes which are contained in the knowledge base for DVT prophylaxis. When a match is found, there is output in the form of a DVT reminder printed on the OR schedule adjacent to the name of the patient, as shown in Appendix G.

A Change in Work Pattern

The letters DVT printed in the OR schedule served as a reminder to ensure that the patients with the reminder had received DVT prophylaxis. The reminder was directed at 3 groups of employees who work with surgical patients and the OR schedule - the nurses on the floor, the surgical staff, and the nurses in the OR. The author met separately with each of these groups to review their contribution to the study.

For the nurses on the floor, a DVT reminder meant to check that the patient had received a dose of anticoagulant (joint replacement cases) or else had elastic stockings in place. Elastic stockings are used at LDS Hospital as an adjunct to pneumatic compression stockings and are placed on the patient's legs by the floor nurses before the patient goes to the OR. The nursing units most affected by this study were 3 North (short stay surgery) and 3 West (orthopedics).

The surgical staff assemble the case carts in a central corridor adjacent to the operating rooms. The personnel who put together the case carts work off both the printed and electronic versions of the OR schedule and used the list of cases provided by the

surgeons to determine when to include compression stockings on the cart along with other operative equipment. The case cart equipment lists were altered to include SCDs for the procedures in the study.

The OR nurses were responsible for placing SCDs on the patients legs after the induction of general anesthetic. When the patient arrived in the operating room, the DVT reminder on the schedule, plus the presence of elastic stockings on the legs, plus the presence of SCDs on the case cart served as 'triple therapy' to ensure that the patient had the SCDs in place prior to starting the procedure.

For joint replacement patients, an established protocol was followed where the nurses on the orthopedic floor checked with the patient to ascertain that the preoperative dose of anticoagulant was properly administered. Patients were expected to take 10 mg of coumadin at home the night before their surgery. If they missed the dose, they were given 5 mg of coumadin the morning of surgery. Postoperatively patients were placed on a sliding scale of coumadin, with the dosage linked to the results of the INR lab test. An exception to the protocol was practiced by 1 surgeon who placed all his total knee joint patients on low molecular weight heparin (LMWH).

As an aide for the nurses, posters with an explanation of the DVT reminder were placed on the floor and in the operating theaters. A sample of the poster is found in Appendix H.

Prior to starting the study, a final meeting was held on October 20, 1997, with the author plus representatives from Material Management, the nursing staff, the operating room staff, Central Processing, Administration, and the HELP programmer who wrote the TAL program for the DVT reminder. This meeting was to ensure coordination between

the different departments whose collaboration was essential for the success of the project. At this meeting, the date to 'go live' with the project was set as November 3, 1997. November 1 and 2 were a Saturday and Sunday, and it was felt best to start on a regular work day with scheduled cases instead of the weekend when only emergency cases were performed.

A week of 'dry runs' were conducted to ensure the program for the reminder was working correctly. While the nursing units and operating room received the regular, unmodified OR schedule, another schedule was printed with the DVT reminder in place and was manually reviewed by the author for accuracy. With no evident problems, the study started on its scheduled date of November 3.

Legal Considerations

A final concern concerned the legal issues at hand. During the meetings with the surgeons, the question was raised of possible increased liability caused by the DVT reminder on the OR schedule. If the surgery schedule indicated that the patient should have some form of prophylaxis, and none was given, and the patient later developed a DVT or PE, was there an increased medical liability?

There are 2 indicators that the DVT reminder did not pose an increased medical liability. The first reassurance came through the example of the preoperative antibiotic reminder already in place on the OR schedule. The 'abx' reminder has been present for over 7 years, and there has never been a lawsuit launched over its inclusion on a patient's record (private correspondence, Dr. Scott Evans to Dr. Robert Patterson, August 8,1997).

The second reassurance came through a conversation with one of Intermountain Health Care's lawyers, Mr. James Gilson, who is familiar with the issues regarding reminders appearing on the OR schedule. According to Mr. Gilson, the presence of a reminder is merely a reflection of practice standards already in the medical community and should not constitute a significant increase in medical liability.

One way to reinforce this concept was the wording found in the footnotes at the end of the surgery schedule. The 'abx' footnote was as follows:

abx - A parenteral antibiotic **is commonly given** for this patient's surgery. If given, prophylactic antibiotics should be started 0 - 2 hours before surgery and discontinued 24 hours after surgery (emphasis by author).

The 'DVT' footnote read as follows:

DVT - Prophylaxis for DVT **is often indicated** for this procedure, and may consist of coumadin, heparin, pneumatic compression devices, or a combination thereof (emphasis by author).

Gathering Data

A feature of the IHC's Enterprise Data Warehouse is that data are not entered and stored there until 6 to 9 months after the patient's discharge date. The search for data in the historic control group was not hindered by this delay, because the control group had surgery 1 year prior to the study group. To accumulate daily information on procedures and prophylaxis for the study group, it was preferable to directly query the HELP system inpatient database, which stores information from the time of admission until 10 days after discharge. Similarly, the AS400 keeps a current database on patients who received

SCDs. The HELP inpatient database and the AS400 database together provided up-to-the-day data for the study group on procedures and prophylaxis, rather than having to wait 6 to 9 months for the same data to appear in the EDW.

To determine if a patient had received DVT prophylaxis, a program was designed for the HELP system to query the inpatient database. Written in PTXT Application Language (PAL), the program compiled a daily list of patients who were scheduled for DVT prophylaxis, and then queried the database to see if an anticoagulant had been given. The query was done in PAL by using a BUILD statement to construct a relationship for patients who had received appropriate anticoagulation, as reflected by a PTXT code for medication in their electronic record. Of note, when building the relationship, it was necessary to query for PTXT code class 48 medications, indicating that the medication had been given, as opposed to class 8 medication codes, which only indicate that a drug has been ordered. A copy of the PAL program is included as Appendix I.

The report also included the date of the procedure, the patient's name, encounter number, OR theater, and PTXT procedure code. The report was generated on the HELP system, and then the data were transferred using a standard File Transfer Protocol program (WS_FTP32.EXE) into Microsoft Word. A typical day's report is included as Appendix J.

Patients who received SCDs for prophylaxis did not have a PTXT code for SCDs in the HELP system. Instead, the AS400 generated a daily list of patients who received SCDs. The AS400 list was then compared to the PAL report for study patients and any exceptions were noted.

In some cases both the daily PAL report for chemoprophylaxis and the daily AS400 report for SCDs did not list a patient who had a procedure in the study. Some nonjoint replacement patients may have been preadmitted to the floor, instead of coming through the same-day admission area. These patients often had SCDs ordered for them on the floor, and this information would not appear in the AS400 daily report for SCDs ordered in the operating room. Another problem arose when an emergency case was added to the list. These patients might receive SCDs but this was not reflected in the daily AS400 report, which was prepared a day ahead of time and dealt with regularly scheduled cases only.

For patients without any apparent DVT prophylaxis, the AS400 database was directly queried using the encounter number generated by the PAL report several days after the surgical procedure. If there was still no indication that SCDs were used, then a search of the paper chart was done to determine if any manual documentation of SCDs or chemoprophylxis existed. The process of determining if study patients received DVT prophylaxis is outlined in the flowchart in Figure 6.

Recording Data

Data was recorded from November 3, 1997 to January 31, 1998 and stored into 2 Excel spreadsheets. The first spreadsheet was a day-to-day tally of the number of cases done and whether or not prophylaxis was provided. The second spreadsheet was a summary of each type of procedure in the study with number of cases performed and number of cases which received prophylaxis. In the second spreadsheet, cases were organized by individual procedure, groups of similar procedures, surgical divisions, and

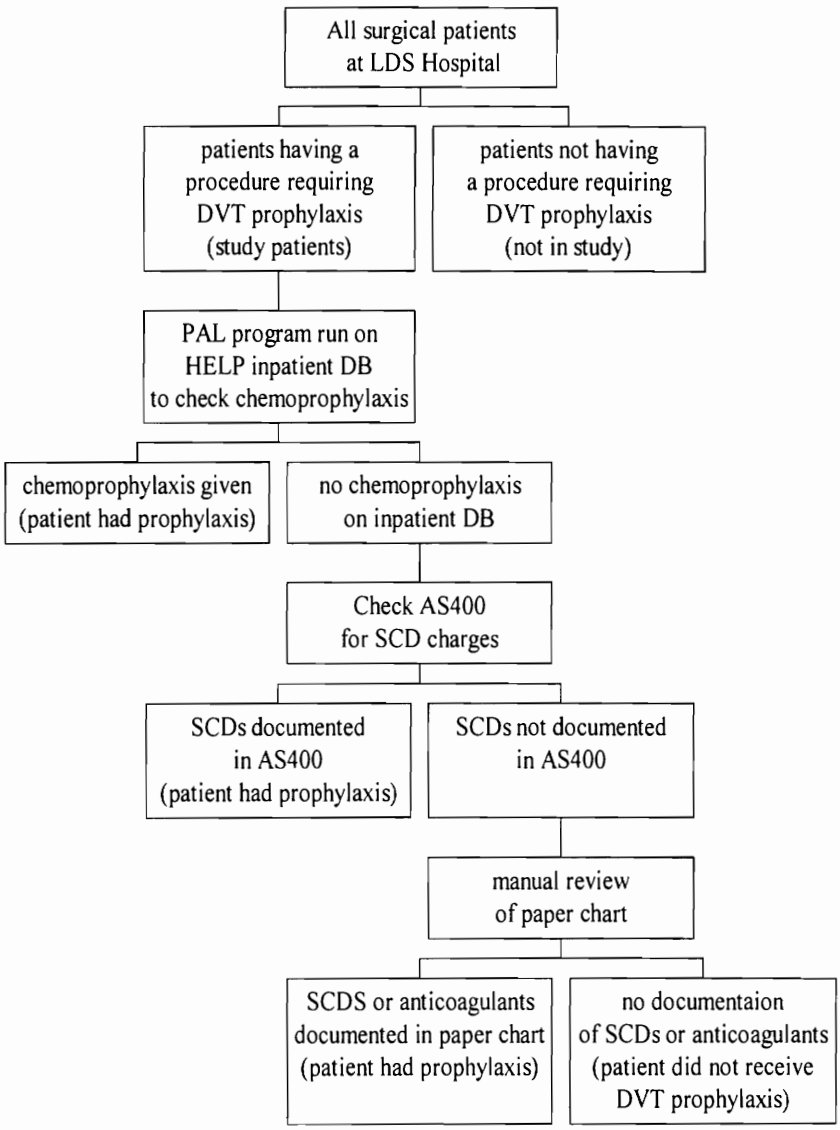

Figure 6. Flowchart of method of determining DVT prophylaxis status.

all cases combined.

III. RESULTS

Data gathering for the study group took place from November 3,1997, to January 31,1998. During this time, 1126 operative cases met the criteria for DVT prophylaxis as established prior to starting the study. The daily enumeration of cases with and without prophylaxis is found in Appendix K. The distribution of cases by division and procedure is in Appendix L.

Summary of Cases in Study

One thousand twenty-seven cases had the DVT reminder appear on the OR schedule. Seventy-six of these cases were mislabeled, i.e., did not require DVT prophylaxis. These 76 cases were not included in the results of this study.

One hundred sixty-two cases were 'add-ons' or emergency cases which went to the OR on an urgent basis. These cases qualified for DVT prophylaxis but did not have the DVT reminder appear on the OR schedule as the patient went straight to surgery.

Thirteen cases which qualified for DVT prophylaxis were regularly scheduled but did not have the DVT reminder appear on the OR schedule; i.e., these cases were missing the DVT prophylaxis label. The reason is explained in the Discussion section, below.

To calculate the number of cases which were included in the trial:

No. of cases = reminders + add-ons + missing labels - mislabels

= 1027 + 162 + 13 - 76

= 1126

Each of the 1126 cases may have had compression devices, anti-coagulation, both or neither. The breakdown by type of prophylaxis is shown in Table 5.

Of the 1126 cases in the study, originally 25 were found not to have any form of DVT prophylaxis listed in the HELP system (anticoagulation) or the AS400 (SCDs). To verify this number, a manual chart review was done of these 25 cases. Of the 25 suspected cases without prophylaxis, 17 had handwritten nurses notes from the operating and recovery rooms indicating that SCDs had been utilized. Therefore, only 8 cases out of 1126 did not receive DVT prophylaxis, giving a DVT prophylaxis rate of 99.3% for the study group. A breakdown of the 8 cases is shown in Table 6.

Over the course of the study, the 1126 cases were done by 54 different surgeons.

- Forty-seven surgeons had no cases that missed prophylaxis.
- Six surgeons had 1 case each that missed prophylaxis.
- One surgeon had 2 cases that missed prophylaxis.

The distribution of cases without prophylaxis by surgeon showed that 1 or 2 surgeons did not account for all of the missed cases

Table 5. Distribution by type of DVT prophylaxis for study cases.

Type of Prophylaxis	n
SCDs	884
anticoagulation	186
both	48
neither	8
total	1126

Table 6. The 8 cases in the study group that did not receive DVT prophylaxis.

Date	Procedure	Comments
Nov 17	laparoscopy, open laparotomy	a 37-year-old female with a history of a pelvic mass
Nov 17	open laparotomy	26-year-old female, laparotomy was preceded by laparoscopy
Dec 16	ORIF tibia	a traumatic fracture in an otherwise healthy 42 year old male
Dec 25	ORIF hip DHS nail	82-year-old male. Lab results showed a normal INR/PTT.
Jan 21	bilateral total knee replacement	This elderly patient had a previous aortic valve replacement and was on coumadin at home. At the time of his orthopedic surgery, his INR was quite high and he was given several units of fresh frozen plasma. In spite of the FFP, his INR remained in the therapeutic range for the 5 days of his admission without any coumadin being given. Thus, although the patient did not receive any DVT prophylaxis during his admission, he was effectively anticoagulated at all times.
Jan 22	exploratory laparotomy	This teenaged male was a pedestrian struck by a car and was brought into emergency in extremis, with injuries to the head, chest, abdomen, and legs. His diagnostic peritoneal lavage was positive and he was taken straight to the OR for emergency laparotomy. Of note, he was hemorrhaging and coagulopathic and therefore not a candidate for anticoagulation. His leg injuries precluded placement of compression devices. Perioperative DVT prophylaxis was not indicated for this patient, who died on the operating room table from his injuries.
Jan 29	posterior repair	This 47-year-old female received elastic stockings but not SCDs. Elastic stockings alone are not considered adequate DVT prophylaxis for the study.
Jan 31	sliding nail R hip	This 78-year-old female was a complex renal patient who underwent dialysis during her admission. INR and PTT were always normal. The patient received no anticoagulation or SCDs during surgery or afterwards.

Statistical Analysis: Comparison with Historic Controls

Originally, all cases eligible for DVT prophylaxis were to be included for determination of statistical significance between the study cases and the control cases. However, there were a few procedures done in the control group November 1996 to January 1997 (referred to as 1996) that were not done in the study group November 1997 to January 1998 (referred to as 1997) and vice versa. For example, in the division of general surgery there were 2 cases of subcutaneous mastectomy done in 1996 and none in 1997. Conversely, there were 2 spleno-renal shunts done in the 1997 study group, and none in the 1996 controls.

If all procedures were included in the analysis, whether or not cases were done for that procedure in both years, the control group and study group would not have a common denominator. Consequently, procedures present in 1 year but not the other were eliminated from the study. The change to a common denominator reduced the number of cases for analysis in 1996 from 948 to 921, and in 1997 from 1126 to 1092.

Statistical analysis was done using 2x2 tables with significance determined by the chi square method. The number of cases with prophylaxis and cases without prophylaxis were compared from the study (November 1997 to January 1998, called 1997 in the table) to the historic controls (November 1996 to January 1997, called 1996 in the table).

An example of the method of statistical analysis is given in Table 7. In the control group, 9 of 26 cases of ORIF tibia had prophylaxis. In the study group, 15 of 16 cases had prophylaxis. The data are set up in a 2x2 table and analyzed by the chi square method. In this example, chi square = 14, and for 1 degree of freedom, $p<.001$.

Table 7. Chi square analysis of ORIF tibia

	1996	1997	total
with prophylaxis	9	15	24
no prophylaxis	17	1	18
total	26	16	42

In the Division of General Surgery, 31 different types of procedures were done in both 1996 and 1997 (see Table 8). When analyzed for statistically significant differences in the rates of prophylaxis between the two, 9 of 31 procedures had a p value of .05 or less. In 22 procedures, there was no statistical difference between the study and the controls. For 18 of these 22 procedures, the preintervention rate of DVT prophylaxis was already greater than 90%. Of the remaining 4 procedures, all had 6 or less cases; statistical significance is difficult to demonstrate with such small numbers.

The 31 procedures were then grouped into 4 types of similar surgeries:

1. breast - mastectomy, modified radical mastectomy, and axillery dissection
2. neck surgery - thyroid, parathyroid, neck dissections, salivary gland surgery
3. laparoscopic surgery - appendectomy, cholecystectomy, hernia, and Nissen
4. open abdominal procedures - all bowel resections, laparotomies, etc.

Results for the grouping into similar procedures are shown in Table 9. All 4 of the groups had a p value of $< .001$. Overall for the Division of General Surgery, when comparing DVT prophylaxis rates for similar cases between the control group and the study group, the study group had significantly higher rates, $p < .001$.

In the Division of Orthopedic Surgery, 10 procedures were compared; only 1 of these showed statistical difference between 1996 and 1997, as shown in Table 10. Of the

Table 8. General surgery cases for 1996 and 1997, showing number of cases by procedure, rate of DVT prophylaxis, chi square and p value.

Procedure	96 cases	96 proph	percent	97 cases	97 proph	percent	chi square	p value
abdominal perineal resection	1	1	100%	3	3	100%	0	NS
anterior resection	5	5	100.0%	4	4	100%	0	NS
axillery node dissection	1	0	0%	10	10	100%	11	<.001
bowel resections	35	34	97%	42	42	100%	1.2	NS
open cholecystectomy	17	17	100%	6	6	100%	0	NS
colectomy, right hemi	15	15	100%	7	7	100%	0	NS
exploratory laparotomy	6	6	100%	78	77	99%	0.1	NS
gastric resection	4	3	75%	5	5	100%	1.4	NS
abdominal wall hernia	32	17	53%	47	47	100%	27	<.001
mastectomy, uni,bi	7	4	57.%	10	10	100%	31	<.001
modified radical mastectomy	27	20	74%	21	21	100%	6.4	<.02
neck dissection/salivary gland	1	0	0%	2	2	100%	0	NS
Nissen fundoplication (open)	4	4	100%	3	3	100%	0	NS
parathyroidectomy	12	6	50%	6	6	100%	4.5	<.05
pelvic/groin lymphadenectomy	3	2	67%	3	3	100%	1.2	NS
sigmoid resection	15	15	100%	3	3	100%	0	NS
splenectomy	6	5	83%	5	5	100%	0.9	NS
thyroidectomy	23	11	48%	19	19	100%	14	<.001
vagotomy	1	1	100%	2	2	100%	0	NS
gastric bypass	14	14	100%	21	21	100%	0	NS
cholecystojejunostomy	1	1	100%	2	2	100%	0	NS
adrenalectomy	4	4	100%	2	2	100%	0	NS
left colectomy	6	6	100%	3	3	100%	0	NS
pancreatic surgery	6	6	100%	13	13	100%	0	NS
closure colostomy	3	3	100%	6	6	100%	0	NS
hepatectomy	9	9	100%	8	8	100%	0	NS
esophago-gastrectomy - abd approach	3	3	100%	4	4	100%	0	NS
laparoscopic cholecystectomy	150	143	95%	168	168	100%	8	<.01

Table 8, continued

Procedure	96 cases	96 proph	percent	97 cases	97 proph	percent	chi square	p value
laparoscopic appendectomy	35	27	77%	39	39	100%	10	<.01
laparoscopic hernia repair	25	23	92%	47	47	100%	3.9	<.05
laparoscopic Nissen fundoplication	9	9	100%	23	23	100%	0	NS
total	480	414	86.3%	612	611	99.8%	86	<.001

Table 9. General surgery procedures for 1996 and 1997, grouped by similar type of operation, showing number of cases, rate of DVT prophylaxis, chi square and p value.

Procedure	96 cases	96 proph	percent	97 cases	97 proph.	percent	chi square	p value
breast surgery	35	24	69%	41	41	100%	15	<.001
neck surgery	36	17	47%	27	27	100%	20	<.001
laparoscopic surgery	219	202	92%	277	277	100%	22	<.001
open abdominal procedures	190	171	90%	267	266	99.6%	24	<.001
total	480	414	86.3%	612	611	99.8%	86	<.001

Table 10. Orthopedic surgery procedures for 1996 and 1997, showing number of cases per procedure, rate of DVT prophylaxis, chi square and p value.

Procedure	96 cases	96 proph	percent	97 cases	97 proph	percent	chi square	p value
ankle fusion	4	3	75%	11	11	100%	2.9	NS
repair of hip fracture	7	5	71%	25	23	92%	2.1	NS
Kuntshcner nailing (IM rodding)	6	5	83%	7	7	100%	0.4	NS
total hip	49	49	100%	65	65	100%	0	NS
total hip - revision	18	18	100%	12	12	100%	0	NS
total knee	50	50	100%	85	84	99%	0.6	NS
total knee - revision	7	7	100%	2	2	100%	0	NS
triple arthrodesis	4	3	75%	1	1	100%	0.4	NS
ORIF femur	22	21	96%	11	11	100%	0.5	NS
ORIF tibia	26	9	35%	16	15	94%	14	<.001
total	193	170	88.1%	235	231	98.3%	19	<.001

9 procedures which did not show significance, 5 had preintervention rates of > 90%, and 4 had 7 or less cases.

The 10 procedures were then grouped into 3 types of similar surgeries:

1. elective nonjoint replacement - ankle fusion, triple arthodesis
2. joint replacement - total hip, total hip revision, total knee, total knee revision
3. trauma fractures - repair of hip fracture, IM rodding, ORIF femur, ORIF tibia

When the orthopedic cases were combined into similar procedures, only the trauma fracture group showed significance, as seen in Table 11. Overall for the Division of Orthopedic Surgery, when comparing DVT prophylaxis rates for similar cases between the control group and the study group, the study group had significantly higher rates, $p < .001$.

In the Division of Gynecologic Surgery, 10 procedures were compared between the study group and the control group. Five of the 10 procedures showed a statistical difference, as seen in Table 12. Two of the remaining 5 procedures had preintervention rates of > 90%, the other 3 procedures had relatively low numbers of procedures.

The 10 procedures were then grouped into 3 types of similar surgeries:

Table 11. Orthopedic surgery procedures for 1996 and 1997, grouped by similar type of operation, showing rate of DVT prophylaxis, chi square and p value.

Procedure	96 cases	96 proph	percent	97 cases	97 proph	percent	chi square	p value
elective nonjoint replacement	8	6	75%	12	12	100%	3.3	NS
joint replacement	124	124	100%	164	163	99%	0.7	NS
trauma fractures	61	40	66%	59	56	95%	16	<.001
total	193	170	88.1%	235	231	98.3%	19	<.001

Table 12. Gynecological surgery cases for 1996 and 1997, showing number of cases by procedure, rate of DVT prophylaxis, chi square and p value.

Procedure	96 cases	96 proph	percent	97 cases	97 proph	percent	chi square	p value
laparotomy	8	4	50%	7	5	71%	0.7	NS
Marshal Marchetti	6	3	50%	9	9	100%	5.6	<.02
radical hysterectomy	1	1	100%	2	2	100%	0	NS
radical vulvectomy	4	3	75%	2	2	100%	0.6	NS
repair of cystocele and rectocele	10	5	50%	10	10	100%	6.7	<.01
total abdominal hysterectomy	87	77	89%	88	88	100%	10.7	<.01
vaginal hysterectomy	50	33	66%	55	54	98%	19	<.001
plain vulvectomy	5	1	20%	2	2	100%	0.5	NS
vaginal vault suspension	3	3		5	5	100%	0	NS
lap assisted vaginal hysterectomy	27	24	89%	30	30	100%	3.5	NS
total	201	154	76.6%	210	207	98.6%	46	<.001

1. open procedures - laparotomy, Marshal Marchetti, radical hysterctomy, total abdominal hysterectomy, vaginal vault suspension
2. vaginal procedures - radial vulvectomy, repair of cystocele and rectocele, vaginal hysterectomy, plain vulvectomy
3. laparoscopic procedures - laparoscopic assisted vaginal hysterectomy

Two of the 3 groups showed statistical difference between the study and control years, seen in Table 13. Overall for the Division of Gynecological Surgery, when comparing DVT prophylaxis rates for similar cases between the control group and the study group, the study group had significantly higher rates, $p < .001$.

The fourth division to participate in the study was the Division of Urology. The majority of surgical procedures done by the group, such as cystoscopy and transurethral resection of the prostate (TURP), did not require DVT prophylaxis. Therefore, the contribution of the Urology division to the numbers of the study was small compared to

Table 13. Gynecological surgery procedures for 1996 and 1997, grouped by similar type of operation, showing rate of DVT prophylaxis, chi square and p value.

Procedure	96 cases	96 proph	percent	97 cases	97 proph	percent	chi square	p value
open procedures	105	88	84%	106	104	98%	13	<.001
vaginal procedures	69	42	61%	74	73	99%	32	<.001
laparoscopic procedures	27	24	89%	30	30	100%	3.5	NS
total	201	154	76.6%	210	207	98.6%	46	<.001

the 3 other divisions. In addition, the rate of DVT prophylaxis in the control group was 100%, leaving no room for improvement. The results for the Division of Urology are shown in Table 14.

The results for all 4 divisions are combined in Table 15. Three of the 4 divisions show statistical significance between the study group and the control group; the total difference is also highly significant ($p < .001$).

In summary, 14 out of 54 individual procedures showed statistically significant improvement in the rate of DVT prophylaxis between the study group and the historic controls. The individual procedures which did not show significant improvement either had small numbers (8 or less cases) or had a prophylaxis rate of > 90% in the historic controls. At the next level of analysis individual procedures were combined into groups

Table 14. Urological surgery cases for 1996 and 1997, showing number of cases by procedure, rate of DVT prophylaxis, chi square and p value.

Procedure	96 cases	96 proph	percent	97 cases	97 proph	percent	chi square	p value
nephrectomy	10	10	100%	5	5	100%	0	NS
radical cystectomy	3	3	100%	2	2	100%	0	NS
prostatectomy	34	34	100%	28	28	100%	0	NS
total	47	47	100%	35	35	100%	0	NS

Table 15. All cases for 1996 and 1997, grouped by surgical division, showing number of cases, rate of DVT prophylaxis, chi square and p value.

Division	96 cases	96 proph	percent	97 cases	97 proph	percent	chi square	p value
general surgery	480	414	86.3%	612	611	99.8%	86	<.001
orthopedic surgery	193	170	88.1%	235	231	98.3%	19	<.001
gynecological surgery	201	154	76.6%	210	207	98.6%	46	<.001
urological surgery	47	47	100%	35	35	100.0 %	0	NS
total all divisions	921	785	85.2%	1092	1084	99.3%	148	<.001

of similar procedures. Seven of 10 groups showed statistically significant improvement. Similarly, at the next level 3 out of 4 divisions showed statistically significant improvement. At the final level of analysis for all procedures in the 4 divisions, the rate of DVT prophylaxis improved from 85.2% in the control group to 99.3% in the study group ($p < .001$).

IV. DISCUSSION

The QI Process

The study was an attempt to increase the rate of perioperative DVT prophylaxis through the use of an automated computerized reminder on the operating room schedule. The methodology followed the basic principles of quality improvement (QI) as taught by Berwick and Williamson (62,102-109). The first step in the QI process was to identify a priority: pulmonary embolism occurring in nonprophylaxed postoperative patients. Postoperative complications can be minimized through appropriate use of preventative measures; thus the next step was to determine the rate of DVT prophylaxis. Overall, for the 4 participating divisions of surgery, the historic rate of prophylaxis was found to be 83.8%, thereby leaving room for improvement - a demonstration of Achievable Benefit Not Achieved (ABNA). Next a goal was set of a Minimum Acceptable Standard (MAS) of 90%, and a sample size calculated. Meetings were held with the surgeons to develop consensus on which cases should receive prophylaxis. Plans were made for an alteration in work process, the crux of which was a computerized DVT reminder on the OR schedule. After appropriate 'buy-in' and orientation from surgical personnel, the changes were implemented and the rate of prophylaxis was remeasured and compared to the pre-intervention rate.

Physician Guidelines

A necessary part of this study was to implement guidelines for DVT prophylaxis, which were based on the recommendations of the American College of Chest Physicians (ACCP) (2). The value of guidelines in clinical practice is generally well accepted in the literature (116-124). However, published studies have shown mixed results with physician compliance (125-133). Despite explicit guidelines, Harpole et al. had little success in persuading physicians to stop ordering abdominal radiographs with a low clinical yield; only 4% of these unnecessary procedures were cancelled (127). On the other hand, in a meta-analysis of 59 published evaluations of clinical guidelines, Grimshaw and Russel concluded that all but 4 showed improvement in the process of care (132).

The differences in physician compliance with guidelines were explained by Grilli and Lomas in their paper on the relationship between compliance rate and the subject of a practice guideline (134). After examining the compliance rate with 143 clinical recommendations in 23 different studies, the authors detected an inverse relationship between the complexity of a guideline and physician compliance. Plainly stated, simple guidelines were more likely to be followed than complicated ones. The principle of clear guidelines was adhered to in the present study, where DVT prophylaxis was a simple yes or no, and the assignment was done automatically by the computer. Consequently, high physician compliance was achieved. Whether or not this level of compliance will continue is addressed later in the Discussion.

Comments on the Results

The results showed a significant increase in compliance, from 85.2% (785/921) in the historic controls to 99.3% (1084/1092) in the study group, when a common denominator was achieved by adjustment for similar procedures. At the level of the individual procedure, 14 out of 54 procedures showed significant improvement; most of those which did not show improvement had a pre-intervention rate of > 90% or else the number of cases was too small ($n < 8$) to demonstrate significance.

Only 8 cases out of an eligible 1126 did not receive prophylaxis, as shown in Table 6. Of these 8 cases, prophylaxis was contraindicated in at least 2 - the elderly male with a high INR from chronic coumadin use, and the young trauma patient with multiple injuries and coagulopathy. An argument could also be made for nonuse in the elderly renal patient, as these individuals often have coagulopathies which are not reflected in the PTT and INR. The fact that these patients did not receive prophylaxis demonstrates the flexibility of the guidelines, where physicians are at liberty to decline prophylaxis if, in their clinical judgment, the patient does not require it.

Five other patients who were eligible for DVT prophylaxis did not receive any therapy. In their paper on measuring and improving physician compliance with clinical practice guidelines, Ellrodt et al. (126) note that noncompliance can be caused by multiple factors, including physician refusal, unclear guidelines, misclassification of patients, change in clinical status and system inefficiencies. The study did not attempt to document physician rationale for not ordering prophylaxis, and therefore the reasons why prophylaxis was not used for these 5 cases is unknown. Any or all of the above factors or other factors not discussed may have been in play.

The study had some patient misclassification. Seventy-six patients who were not in the study were mistakenly labeled with the DVT reminder, a result of the work patterns developed by the personnel who assemble the case carts and assign the procedure codes. In the HELP system, each surgical procedure has a unique PTXT code. For example, epigastric hernias are 14.77 and umbilical hernias are 14.74. However, the case carts for the 2 procedures are identical; therefore for the convenience of the case cart assemblers both procedures are assigned PTXT code 14.77.

In developing consensus on which procedures required prophylaxis, the general surgeons decided to cover epigastric hernias, but not umbilical hernias, as umbilical hernia repair almost always takes less than 30 minutes and does not fit into the ACCP recommendations (2). With umbilical hernias assigned the same PTXT code as epigastric hernia, the umbilical cases were flagged with the DVT reminder on the OR schedule. Similar situations arose with biopsy of cervical lymph node (assigned the PTXT code for neck dissection), breast biopsy (mastectomy), drainage of groin abscess (groin dissection), knee manipulation under anesthetic (knee replacement), and several other procedures. Overall, 76 out of 1027 DVT labels were inappropriate, an error rate of 7.4%. These cases were not included in the results of the study.

Two tactics attempted to remedy the problem of deliberate misassignment PTXT codes. The first was to speak with the personnel who assemble the case carts and ask them to alter their work process so that the correct procedure codes are assigned for each case. The suggestion to change established work patterns met with some resistance. The proposed change would require considerable effort on the part of the surgical staff as all new case carts must be itemized and then approved by the surgeons. The case cart

assemblers did agree not to include SCDs on the case carts where prophylaxis was not indicated, even if there was a reminder on the OR schedule. The second strategy was to speak with the head nurse in the short stay area and make a similar request, i.e., not to put elastic stockings on patients going for minor procedures, even if there was a DVT reminder on the OR schedule. This unit had a paper copy of all procedures included in the study, and so were able to screen patients appropriately.

Another form of misclassification occurred when patients who were eligible for DVT prophylaxis did not receive a reminder on the OR schedule. This happened 13 times out of 964 cases (1027 labels, minus 76 inappropriate labels, plus 13 missed labels), an error rate of 1.3%. Two situations caused the error of omission to occur. The first cause was when a case was mistakenly assigned a PTXT code which did not correspond to the written description of the procedure. For example, a laparoscopic inguinal hernia repair, which was included in the study, was assigned the PTXT code for an open inguinal hernia repair, which was not part of the study. The second cause occurred when the patient had the procedure changed and the original PTXT code was not changed to reflect the new procedure. For example, a patient may have had a trans-thoracic esophagectomy scheduled (thoracic cases were not part of the study) where no reminder would occur, and then had the case changed to an abdominal approach, which was in the study. Although the text description of the case was altered, the PTXT code was not, and the DVT reminder did not appear on the OR schedule.

Another area of the study that merits comment is the add-on emergency cases. Regularly scheduled cases were booked days or weeks in advance and were screened ahead of time via the time-drive mechanism in the TAL program. Eligible cases then had

the DVT reminder appear on the OR schedule, which was printed the morning of surgery. Emergency cases were added during the day on an ad hoc basis; such a case may have been booked at 10:00 a.m. and done at 2:00 p.m., not allowing time for the DVT reminder to appear on the OR schedule for that day.

A potential solution to the problem of the static and quickly outdated paper OR schedule would be to introduce a 'real time' on screen OR schedule, where everyone is apprised of changes to the schedule as they happen. A similar system is already in use in the airline industry, with flight arrivals and departures updated as soon as information becomes available. Although not currently in place at LDS Hospital, the 'real time' OR schedule may be a future application of informatics technology.

Of the 1126 cases in the study, 162 were add-ons, 14.4% of the total. These cases were retained in the study as the timing of bookings had not been adjusted for in the historic controls. Of the 8 cases that missed prophylaxis, 4 occurred in the 162 add-on cases and the other 4 occurred in the 964 scheduled cases. The difference was statistically significant with chi square = 8.6, $p < .01$. In other words, prophylaxis was more likely to be missed for an add-on case than for a scheduled case. Still, the add-on cases had a much higher rate of prophylaxis (158/162, 97.5%) than the historic controls from the previous year (794/948, 83.8%), with chi square = 21, $p < .001$.

Why was the rate of prophylaxis so high for patients who did not have the benefit of a DVT reminder on the OR chart? The answer was likely a combination of a consensus on procedures, a heightened awareness of the problem and a change in work process which was in effect even when the reminder was not present. Take the example of the Division of Orthopedic Surgery. Years prior to the present study, these surgeons

had reached consensus on their own that total joint replacement surgery patients should have DVT prophylaxis. The rate for total joint replacement surgery in the historic controls was 100% (124/124); the rate during the study period was 99.4% (163/164); the difference was not significant.

However, prior to the study there was no consensus on prophylaxis for tibial fractures, and the rate of prophylaxis for ORIF tibia was only 34.6% (9/26) in the historic controls. The rate improved to 93.8% (15/16) during the study, a significant difference with chi square = 14, $p < .001$. Yet most of these cases were add-ons; a fractured tibia was done right away as an emergency case and no DVT reminder appeared on the OR schedule. During the study period, all orthopedic surgeons agreed to treat all tibia fractures with prophylaxis. Furthermore, the case cart assemblers also knew that all tibia fractures received compression devices, whereas before it was only at the prerogative of the individual surgeon.

Although it is speculative to assume a causal relationship, the combination of consensus, increased awareness and a change in work pattern may have led to the increased compliance, even in the absence of the DVT reminder. Rather than attribute the success of this study solely to the computerized reminder, it is likely more accurate to state that the reminder was part of a process which improved the delivery of care.

Cost Issues

The issue of cost was not addressed specifically in this study. Several studies have demonstrated the cost effectiveness of DVT prophylaxis (58,59), but any attempt at

cost effectiveness must take multiple factors into account, including the expense of materials in the hospital of interest.

At LDS Hospital, the different forms of prophylaxis have the following costs displayed in Table 16. Cost of DVT prophylaxis will obviously vary according to the type and duration of therapy chosen. Table 17 calculates cost of prophylaxis for a single day of therapy, and a week of therapy.

Obviously, the cost of prophylaxis will vary greatly according to choice and duration of therapy. In addition to the costs of the medications or devices, additional expenses must also be considered, such as monitoring of lab tests and complications of prophylaxis. Such an analysis is beyond the scope of the present study.

Limitations of This Study

The study has several limits, including verification of data quality, measurement of process outcomes in lieu of clinical outcomes and no measurement of any attrition.

Table 16. The cost of various forms of DVT prophylaxis at LDS Hospital, February 1998.

Type of Prophylaxis	Cost
Sequential Compression Devices	$11.25 per day for the machine, plus a one time charge of $58.00 for the stockings
Plexipulse Compression Boots	$24.90 per day for the machine, plus a one time charge of $50.00 for the boots
coumadin (oral)	$0.06 per dose, plus an administration charge of $2.33 per dose, for a total of $2.39 per dose
unfractionated heparin (injection)	$0.03 per dose, plus an administration charge of $12.20 per dose, for a total of $12.23
low molecular weight heparin (injection)	$12.21 per dose, plus an administration charge of $12.20 per dose, for a total of $24.41

Table 17. The cost of various forms of DVT prophylaxis for a single day and for a week, LDS Hospital, February 1998.

Type of Prophylaxis	Cost for a single day	Cost for a week
Sequential Compression Devices	$69.25	$137.25
Plexipulse Compression Boots	$74.90	$224.30
coumadin (oral)	$2.39	$16.73 (plus monitoring)
unfractionated heparin (injection)	$12.23 (single dose)	$171.22 (b.i.d.)
low molecular weight heparin (injection)	$24.41 (single dose)	$341.74 (b.i.d.)

The cases during the period of the study were tallied on a day-to-day basis utilizing the operating room schedule and inpatient paper and electronic charts. By contrast, the rates for the historic controls were derived from an administrative database. Administrative databases have been criticized as an inaccurate reflection of the clinical record (135,136). The data in the EDW database came from a variety of sources. The ICD9 procedure codes in the EDW were originally PTXT procedure codes in the HELP system. Medications listed in the EDW were PTXT codes in HELP before, then charge codes in the AS400 financial system. The charge codes for SCDs came directly from the AS400 without ever being part of the HELP system. The question begs - how accurate is this information?

Key causes of difficulties with information quality were outlined by Strong et al. (137). In brief, data may be inaccurately produced, incorrectly stored in a database, or retrieved in an erroneous fashion.

It is possible that a patient received a therapy that was not captured in the computer system (inaccurate production of information), more probable for SCDs than

anticoagulants. Nurses have a strict process for recording medications in the electronic chart, so lack of a medication code is unlikely to be a source of error. During the 3 month study period, no instances were discovered of an anticoagulated patient who did not have the medication recorded in the electronic chart (234 cases). More likely, a patient might receive SCDs without this being recorded in the AS400 computer, and therefore this information would not appear in the daily listings of SCD devices or as a charge code in the EDW.

Electronically unrecorded SCDs occurred 17 times out of 932 cases during the study, an incidence of 1.8%. The majority of the cases (11/17) were add-ons and occurred late at night or on weekends. SCD machines should be serviced between patients and the charge code information is captured with the servicing. With late night cases the same machine was likely used for 2 patients without being serviced in between. Although reuse of SCD machines is not standard nursing practice, it may have been necessitated by an additional machine not being available at that time of day. Prophylaxis with a nonserviced machine is better than no prophylaxis at all. The problem of electronically unrecorded SCDs was an unrecognized process error identified by the study.

The small number of unrecorded SCD machines likely had minimal impact on the results. Even if an additional 2% of the historic control patients had received SCDs, the difference between the study and control groups would still be highly significant.

One unanticipated challenge with information quality occurred in the historic controls, when the cases with DVT prophylaxis were manually audited for accuracy. Of the 264 cases, 73 were removed from the study, a high number (see Figure 3). Forty-five

cases were removed because of incorrect codes. Nine cases had an incorrect procedure code while 36 cases had an incorrect facility code. The study did not attempt to document where errors in coding occurred. The discrepancies between the paper and electronic records outline the problems that can arise when multiple records exists and information is converted from one form to another. Maintenance of data integrity is an important issue, but not the focus of the study and is not commented on further except to repeat that data accuracy was ensured by the manual audit of records.

Another limitation to the study was process outcomes were measured in lieu of clinical outcomes. Ultimately, clinical outcomes are the object of interest. For example, in their work with a reminder for preoperative antibiotics, Classen et al. initially showed a change in process outcome (an increased rate of pre-operative antibiotic administration from 40% to 99%), and in a follow up study were also able to demonstrate a decrease in the incidence of postoperative wound infections, from 2% to 0.4% (93).

Ideally, the present study would have shown a decrease in the rate of pulmonary embolism (PE). Two difficulties exist with demonstrating a decrease in the incidence of postoperative PEs. The first is that PEs are a relatively rare event, occurring only once per month on average in surgical patients without prophylaxis at LDS Hospital according to the ICOPER data (see Appendix 3). Prophylaxis can prevent up to 80% of PEs but does not eliminate them all. To demonstrate a change from an average of 10-12 PEs per year to an average of 3-4 PEs per year would require gathering data for several years instead of the 3 months allotted to the study.

The second difficulty is that not all patients return to LDS Hospital for their postoperative care. A PE can occur anywhere from 1 week to several months after a

surgical procedure (21). By that time the patient may have returned home to a different city or state, and could be treated for complications at another facility without that data ever making its way into the patient's record at LDS Hospital. Also, the presentation of a PE may be sudden death, yet families of elderly patients will frequently decline autopsies and the cause of death remains unknown. Given the current patterns of practice the true incidence of PE in patients who have had their surgery at LDS Hospital remains unknown.

Is it acceptable to perform a study that measures process outcomes instead of clinical outcomes? In their paper on designing studies of computer-based alerts and reminders, Rind et al. address this question and conclude that the clinical value of measuring process outcomes can be determined if adequate data exist for the procedure or behavior that the reminder addresses (69). Investigators have thoroughly documented the effectiveness of prophylaxis against postoperative DVT and PE (2,3). The purpose of the study was not to demonstrate a relationship between prophylaxis and thromboembolism, but rather to increase appropriate use of prophylaxis. Although the study would be strengthened if it had shown a decrease in thromboembolic disease, it may be safely inferred that an increase in the rate of prophylaxis will lead to a decrease in the incidence of DVT and PE.

Finally, the study showed an increase in the rate of prophylaxis during the 3 months of the trial, but it is unknown if this effect will be sustained after the study is concluded. The effect of a computer generated alert is subject to attrition, as was seen in the Veterans Affair Collaborative Controlled Clinical Trial #9 (138). Ideally, DVT prophylaxis rates at LDS Hospital should be measured again in a year to see if

compliance remains high. With the combination of a consensus among the surgeons, a change in work patterns among surgical personnel, heightened awareness of the need for DVT prophylaxis and a consistent computerized reminder, the rate of prophylaxis will hopefully remain close to its current level of 99.3%.

V. SUMMARY AND CONCLUSION

The study was entitled "A Computerized Reminder for Prophylaxis of Deep Vein Thrombosis in Surgical Patients." The study examined the historic rate of DVT prophylaxis for surgical patients at LDS Hospital and found room for improvement. Consensus was developed with the hospital's surgeons over which procedures should have prophylaxis. An automated reminder was then placed on the hospital's computer system to flag those patients for whom DVT prophylaxis was indicated. Surgical personnel including surgeons, nurses and case cart assemblers were alerted to a change in their work pattern. After gathering data for 3 months on 1126 patients, the rate of DVT prophylaxis in surgical patients improved from 83.8% in the historic controls to 99.3% in the study group. The difference in rates was highly statistically significant ($p<.001$).

The success of the study was recognized by members of the participating divisions of surgery, and the DVT reminder was left in place after the conclusion of the study. The reminder will be maintained at LDS Hospital by the programmer and pulmonary physician who aided in the study.

The study has shown that a computerized reminder, combined with other measures such education, forming consensus and changing work patterns, appeared to be an effective method of increasing the rate of DVT prophylaxis in surgical patients.

APPENDIX A

TEXT OF LETTER OF INVITATION TO PARTICIPATE IN THE DVT PROPHYLAXIS TRIAL

Dear Dr. _____

Dr. Robert Patterson is a general surgeon and informatics student at the University of Utah who is working on a project concerning DVT prophylaxis in surgical patients here at LDS Hospital. His plan is to place a computerized reminder on the OR schedule, similar to what is currently done with preoperative antibiotics.

He and I have already met with the Departments of General, Orthopedic, and OB/GYN surgery and have their interest and support in the project. At a recent meeting of the Surgical Executive Committee, it was suggested that he extend his project to cover all surgical patients at LDSH, not just those in the aforementioned departments.

Dr. Patterson would like to make a brief presentation in your departmental meeting, which can include data specific to the procedures performed by your surgeons. He would then like to work with an individual in your department to develop a list of all procedures for which DVT prophylaxis is considered appropriate. This will also afford you an opportunity to criticize and make suggestions for his work.

I believe this study will be of value to both patients and physicians here at LDS Hospital. Your cooperation in this matter will certainly enhance the project and be much appreciated. Please let me know when such a presentation might be made to your department.

Sincerely,

Greg Elliott MD

APPENDIX B

DVT PROPHYLAXIS RATES FOR SELECTED PROCEDURES, LDS HOSPITAL, 1996

Table 18. General Surgery procedures, with corresponding ICD9 codes, number of cases, number of cases with prophylaxis, and rate of prophylaxis expressed in percent.

Procedure	ICD9	Cases	Prophylaxis	%
lap cholecystectomy	5123	562	494	88
open cholecystectomy	5122	69	67	97
abdominal wall hernia	5351 5359 5361 5369	133	63	47
partial or total gastrectomy	4381	0		
	4389	1	1	100
	435	2	2	100
	436	4	4	100
	437	11	11	100
esophagogastrectomy	4399	4	4	100
esophagectomy	4240 4241 4242	5	5	100
small bowel resections	4561 4562 4563	61	60	98
colectomy (partial)	4571 4572 4573 4574 4575 4576 4579	147	146	99
colectomy, total intra-abd	458	14	14	100
anterior resection	4863	8	8	100
APR	485	4	4	100
closure of ostomy	4651 small	5	4	80
	4652 colon	16	15	94
exploratory laparotomy	5411	20	13	65
Whipple	527	20	20	100
pancreatic surgery	5251 5252 5253 5259	10	10	100
hepatectomy	5022 partial	25	25	100
	503 lobe	19	18	95
thyroid	062	26	14	54
	064	27	13	48
parathyroid	0681	2	1	50
	0689	31	18	58
adrenalectomy	0722	6	6	100
	0729	0		
simple mastectomy	8541 unilat	20	10	50
	8542 bilat	3	2	67

Table 18 continued

Procedure	ICD9	Cases	Prophylaxis	%
modified radical mastectomy	8543 unilat	78	47	60
	8544 bilat	4	4	100
radical mastectomy	8545 8546	0		
Total for General Surgery		1337	1103	82.5

Explanation of Column Headings:
Procedure - the surgical procedure
ICD9 - the ICD9 code(s) for the surgical procedure
Cases - the number of cases done for the procedure
Prophylaxis - the number of cases which received DVT prophylaxis
% - cases which received prophylaxis over cases done

Table 19. Orthopedic Surgery procedures, with corresponding ICD9 codes, number of cases, number of cases with prophylaxis, and rate of prophylaxis expressed in percent.

Procedure	ICD9	Cases	Prophylaxis	%
Total hips	8151	193	189	98
Revision hips	8153	78	73	94
Total knees	8154	206	199	97
Revision knees	8155	23	20	87
ORIF tib/fib	7936	124	33	27
ORIF femur	7935	119	96	81
Lower extremity amputations	8412	13	8	61
(except toes)	8414	3	1	33
	8415	16	10	63
	8417	10	7	70
	8419	1	1	100
ORIF humerus	7931	25	5	20
ORIF radius/ulna	7932	53	5	9
Shoulder repair	8180 8181	142	6	4
	8182 8183			
Total for Orthopedic surgery		1006	653	64.9

Explanation of Column Headings:
Procedure - the surgical procedure
ICD9 - the ICD9 code(s) for the surgical procedure
Cases - the number of cases done for the procedure
Prophylaxis - the number of cases which received DVT prophylaxis
% - cases which received prophylaxis over cases done

Table 20. Gynecological Surgery procedures, with corresponding ICD9 codes, number of cases, number of cases with prophylaxis, and rate of prophylaxis expressed in percent.

Procedure	ICD9	Cases	Prophylaxis	%
total abdo hysterectomy	684	305	265	87
vaginal hysterectomy	685	304	205	67
oophrectomy and salpingo-oophrectomy	6551 6552 6561 6562	46	31	67
cystocele and rectocele	705	39	22	56
Total for Gynecologic Surgery		694	523	75.4

Table 21. Urological Surgery procedures, with corresponding ICD9 codes, number of cases, number of cases with prophylaxis, and rate of prophylaxis expressed in percent.

Procedure	ICD9	Cases	Prophylaxis	%
complete nephrectomy	5551 5552 5553 5554	68	64	94
partial nephrectomy	552	4	4	100
sphincterotomy of bladder	5791	17	2	12
retropubic urethral suspension	595	27	15	56
TURP	6021 6029	124	14	11
prostatectomy suprapubic	603	1	1	100
retropubic	604	2	2	100
radical	605	95	93	98
Total for Urological Surgery		338	195	57.7

Explanation of Column Headings:
Procedure - the surgical procedure
ICD9 - the ICD9 code(s) for the surgical procedure
Cases - the number of cases done for the procedure
Prophylaxis - the number of cases which received DVT prophylaxis
% - cases which received prophylaxis over cases done

Table 22. Totals for all 4 Divisions

Division	Cases	Prophylaxis	%
General Surgery	1337	1103	82.5
Orthopedic Surgery	1006	653	64.9
Gynecologic Surgery	694	523	75.4
Urological Surgery	338	195	57.5
Grand Total	3375	2474	73.3

APPENDIX C

DATA FROM THE ICOPER STUDY, LDS HOSPITAL

Table 23. Data from the ICOPER study, LDS Hospital

Pt	Proph	Division	Procedure
029	Yes	Ortho	repair of fractured femur
103	Yes	Ortho	total knee
021	Yes	Ortho	total hip
079	Yes	Ortho	lumbar spine decompression
050	No	Ortho	cervical discectomy
052	No	Ortho	repair of hip fracture
067	No	Ortho	knee arthroscopy
074	No	Ortho	ORIF tibial plateau
085	No	Ortho	removal of bone spur from foot
064	Yes	Gyne	debulking of ovarian tumor
078	No	Gyne	D&C
083	No	Gyne	total abdominal hysterectomy
044	No	Gyne	pelvic lymphadenectomy
013	No	Gyne	total abdominal hysterectomy
102	No	Gyne	total abdominal hysterectomy
047	Yes	GenSurg	incisional hernia repair
098	No	GenSurg	Nissen fundoplication
033	No	GenSurg	biliary reconstruction/liver transplant
016	No	GenSurg	thyroidectomy
005	No	GenSurg	colectomy
065	No	GenSurg	abdominoplasty
087	No	GenSurg	laparoscopic appendectomy
046	No	Neuro	craniotomy
028	Yes	Thoracic	coronary artery bypass
097	Yes	Thoracic	coronary artery bypass
020	No	Other	debridement of shoulder post acromioplasty
048	No	Other	cyst on hand

Pt:	patient number as enrolled in ICOPER study
Proph	indicates whether or not the patient had prophylaxis at the time of surgery
Department	indicates which surgical division did the procedure
Procedure	the specific surgical procedure which preceded the pulmonary embolism

APPENDIX D

SUMMARY OF ACCP RECOMMENDATIONS

FOR DVT PROPHYLAXIS

1. Low Risk Patients
   <40 years old
   minor surgery
   no other risk factors

   DVT Prophylaxis: none recommended

2. Moderate Risk Patients
   >40 years old
   major surgery
   no other risk factors

   DVT Prophylaxis: ES or LDUH or IPC

3. High Risk Patients
   >40 years old
   major surgery
   additional risk factors

   DVT Prophylaxis: LDUH or LMWH or IPC

4. Very High Risk Patients
   >40 years old
   major surgery
   previous DVT
   malignant disease

   DVT Prophylaxis: LDUH or LMWH, plus IPC

ES: graded compression elastic stockings, applied pre-op, worn until patient is ambulatory.
IPC: intermittent pneumatic compression, applied with induction of general anesthetic, continued post-op until patient is ambulatory.
LDUH: low dose unfractionated heparin, given as 5,000 units s.q. q12h or q8h. First dose is given 1-2 hours pre-op. Continued post-op until patient is ambulatory.
LMWH: low molecular weight heparin, for example, enoxaparin 30 mg s.q. q12h or 40 mg s.q. once a day.

APPENDIX E

PTXT PROCEDURE CODES FOR DVT PROPHYLAXIS

Table 24. General Surgery PTXT procedure codes for DVT prophylaxis

PTXT Code	Text (from PTXT codes)
14.1	abdominal perineal resection
.2	ampullary spincteroplasty
.5	anterior resection
.6	antrectomy - feeding gasrtotomy
.10	axillery node dissection
.11	bowel resection
.14	cholecystectomy
.15	colectomy
.17	colostomy
.21	excision of adrenal mass
.24	exploratory laparotomy
.25	exploratory laparotomy with bowel instruments
.28	gastrectomy
.29	gastrojejunostomy
.30	gastroplasty
.34	hiatal hernia repair
.35	incisional hernia repair
.44	mastectomy
.46	modified radical mastectomy
.48	neck dissection for removal of salivary gland
.49	Nisson fundoplication
.50	parathyroidectomy
.51	panniculectomy
.52	parotidectomy
.53	pelvic lymphademectomy
.55	pyeloroplasty
.57	radical groin dissection
.58	radical mastectomy
.59	radical neck dissection
.61	roux-en-Y
.64	sigmoid resection
.65	splenectomy
.66	staging laparotomy
.68	subcutaneous mastectomy
.69	subtotal gastrectomy
.70	subtotal thyroidectomy
.73	thyroidectomy
.75	vagotomy
.77	ventral hernia repair
.78	gastric bypass
.83	cholecystojejunostomy

Table 24 continued

PTXT Code	Text (from PTXT codes)
.84	adrenalectomy
.85	hemi-pelectomy
.88	pelvic exenteration
.89	porta-caval shunt
.91	transrectal tumor
.95	Whipple
.98	cholecystostomy
.108	radical total gastrectomy - thoraco-abd approach
.111	colectomy, perineal pull through
.112	breast biopsy, possible mastectomy
.113	excision sub-Q maxillary gland
.114	chole & grams
.115	common duct exploration
.116	gastric resection
.117	transverse colectomy
.118	ileostomy
.119	jejuno-jejunostomy
.121	left colectomy
.122	colostomy - Wangenstein transverse colon
.124	cholecystectomy with NFP
.126	partial colectomy with proctopexy
.128	trans rectal tumor with appendectomy
.130	wide breast biopsy, axillery node dissection
.136	Whipple with IORT
.143	gastric bypass with chole
.145	resect perineal tumor
.148	ventral hernia with panniculectomy
.154	pancreactomy
.155	closure colostomy
.159	hepatectomy
.162	esophago-gastrectomy - abd approach
.166	loop colostomy with bridge
.167	vagotomy/antrectomy
.170	spleno-renal shunt
.172	total colectomy, ileostomy, endo-rectal pull through
.175	right hepatic lobe resection
.176	left hepatic lobe resection
.177	pancreatic abscess (debridement)
.178	abdominal debridement
.180	laparoscopic cholecystectomy, possible open
.181	laparoscopy (general surgery)

Table 24 continued

PTXT Code	Text (from PTXT codes)
.182	laparoscopic appendectomy
.183	laparoscopic inguinal hernia repair
.184	laparoscopic bowel resection
.186	laparoscopic Nissen fundoplication
.188	laparoscopy/liver biopsy
.190	laparoscopic colostomy take-down
.191	laparoscopic right colectomy
.192	laparoscopic colectomy
21.30	thoraco-abdominal esophageal resection
21.34	excision of esophageal diverticulum
21.73	spenal renal shunt

Table 25. OB/GYN Surgery PTXT procedure codes for DVT prophylaxis

PTXT Code	Text (from PTXT codes)
15 .9	laparotomy, BSO, incidental appendectomy
.10	laparotomy, cysto, and procto
.11	laparotomy, ectopic pregnancy
.12	laparotomy, ovarian cystectomy
.13	laparotomy, tubal plasty
.14	lap, uterine susp, pre sacral neurectomy
.18	laparoscopy, hysterectomy
.20	laparoscopy, laparotomy, D & C
.21	laparoscopy, laparotomy for infertility
.22	laparoscopy, laparotomy for pelvic pain
.23	laparoscopy, laparotomy, tubal plasty
.24	laparoscopy, laparotomy, tubal reanastamosis
.30	Marshal Marchetti
.33	radical hysterectomy
.34	radical vulvectomy
.35	repair of cystocele
.36	repair of cystocele and rectocele
.37	repair of rectocele
.39	total abdominal hysterectomy
.40	TAH, MMK
.41	TAH, Marshal Marchetti, repair of cystocele and rectocele
.42	total abdominal hysterectomy, repair of rectocele
.43	vaginal hysterectomy
.44	vaginal hysterectomy, cysto, procto, and rectocele
.45	vaginal hysterectomy and rectocele repair
.46	vag hyst A&P repair
.47	vaginal vault suspension, abdominally
.48	vaginal vault suspension, vaginally
.49	wedge resection of ovary
.52	exploratory laparotomy, lysis of adhesions
.53	exploratory laparotomy, uterine suspension
.54	expl lap, wedge resection of ovary
.55	colpoleisis
.62	vaginal hysterectomy, anterior repair
.64	plain vulvectomy
.65	total abdominal hysterectomy, BSO
.66	total abdominal hysterectomy with nodes
.67	vaginal hysterectomy with cone biopsy
.68	pre-sacral neurectomy
.69	exploratory laparotomy, insertion of template
.72	bladder suspension

Table 25 continued

PTXT Code	Text (from PTXT codes)
.73	D&C, TAH
.75	laparotomy, tubal plasty, microsurgery
.77	tubal reanastamosis
.78	myomectomy
.81	La Forte procedure
.85	TAH/Birch urethropexy
.88	TAH, Birch, rectocele and cystocele repair
.89	vaginal rectal fistula repair
.90	vaginal vault suspension, abdominally and vaginally
.96	para-vaginal retropubic repair
.97	lateral vaginal wall suspension
.101	laparoscopic assisted vaginal hysterectomy
.102	TAH, abdominal vag sacropexy, lat vag vault suspension
.106	sacral spinous vaginal vault suspension
.109	radical hysterectomy with lymphadenectomy
.110	radical hysterectomy with select nodes, cysto, procto, EUA
.111	neo-vagina with split thickness skin graft
.112	radical hysterectomy with bowel resection
.113	vaginectomy

Table 26. Orthopedic Surgery PTXT procedure codes for DVT prophylaxis

PTXT Code	Text (from PTXT codes)
18.6	ankle fusion
.36	Haggi hip pinning
.37	high tibia osteotomy
.38	hip pinning
.41	sliding nail / DHS hip pinning
.47	Knowles hip pinning
.48	Kuntshcner nailing (IM rodding)
.57	ORIF hip joint
.58	ORIF large extremity
.68	proximal tibia osteotomy
.73	Thompson/Austin-Moore hip
.74	total ankle
.75	total hip
.76	total hip - cementless
.77	total hip - revision
.78	total knee
.81	triple arthrodesis
.88	key free hip pinning with cement
.102	ORIF femur
.108	ORIF tibia
.121	arthroscopy - high tibia osteotomy
.132	reconstruction of knee
.142	ORIF - tibia plateau
.177	key free hip pinning with cement
.209	IM nailing tibia
.211	total knee - revision
.212	ORIF femoral condyle
.223	ankle fusion with bone graft
23.5	distal tibia osteotomy
23.21	Richards tibial nailing
23.22	Richards femoral nailing
23.75	total hip - with cement
23.82	Thompson Austin Moore endoprosthesis
23.83	triple hip osteotomy
23.89	bilateral total knee
23.106	ankle fusion

Table 27. Urological Surgery PTXT procedure codes for DVT prophylaxis

PTXT Code	Text (from PTXT codes)
22.5	bladder diverticulectomy
.11	cutaneous ureterostomy
.27	ileo conduit
.28	iliac node dissection
.29	iliac node dissection, I125 seeds
.32	nephrectomy
.33	nephrostomy
.34	open urethral suspension
.37	perineal prostatectomy
.40	prostate/vesicle/rectal fistula
.41	pyelolithotomy
.42	pyeloplasty
.43	pyeloureteroplasty
.45	radical cystectomy with ilio conduit
.46	radical perineal prostatectomy
.47	renal exploration
.48	retro-pubic prostatectomy
.57	suprapubic prostatectomy
.65	uretero/ileo anastamoses
.66	ureterolithotomy
.67	ureteroplasty
.83	vesico/vaginal fistula
.84	graft patch urethroplasty
.91	lymphadenectomy, rad ret-pub pros
.105	penectomy

APPENDIX F

RATES OF DVT PROPHYLAXIS IN THE HISTORIC CONTROL GROUP

Table 28. General Surgery procedures at LDS Hospital, November 1996 to January1997. For each procedure the table lists the corresponding PTXT code, the ICD9 code, number of cases done, number of cases with prophylaxis, and rate of prophylaxis expressed in percent.

General Surgery Procedure	PTXT	ICD9	96 cases	96 proph	percent
abdominal perineal resection	14.1	48.5	1	1	100.0%
anterior resection	14.5	48.63	5	5	100.0%
axillery node dissection	14.1O	40.23	1	0	0.0%
bowel resections	14.11	46	35	34	97.1%
open cholecystectomy	14.14	51.22	17	17	100.0%
colectomy, right hemi	14.15	45.73	15	15	100.0%
exploratory laparotomy	14.24	54.11	6	6	100.0%
gastric resection	14.6	43.6	4	3	75.0%
hiatal hernia repair	14.34	53.7	2	2	100.0%
abdominal wall hernia	14.35.77	53.5161	32	17	53.1%
mastectomy, uni,bi	14.44	85.4142	7	4	57.1%
modified radical mastectomy	14.46	85.43	27	20	74.1%
neck dissection for removal of salivary gland	14.48	26.32	1	0	0.0%
Nissen fundoplication	14.49	44.66	4	4	100.0%
parathyroidectomy	14.51	6.89	12	6	50.0%
pelvic lymphadenectomy	14.53	40.3	3	2	66.7%
sigmoid resection	14.64	45.76	15	15	100.0%
splenectomy	14.65	41.5	6	5	83.3%
subcutaneous mastectomy	14.68	85.35	2	0	0.0%
thyroidectomy	14.73	6.451	23	11	47.8%
vagotomy	14.75	44.02	1	1	100.0%
gastric bypass	14.78	44.31	14	14	100.0%
cholecystojejunostomy	14.83	51.32	1	1	100.0%
adrenalectomy	14.84	7.2122	4	4	100.0%
pancreatic surgery	14.95	52.7	6	6	100.0%
left colectomy	14.121	45.75	6	6	100.0%
closure colostomy	14.155	46.52	3	3	100.0%
hepatectomy	14.159	50.223	9	9	100.0%
esophago-gastrectomy - abd approach	14.162	43.5	3	3	100.0%
laparoscopic cholecystectomy, possible open	14.18O	51.23	150	143	95.3%
laparoscopic appendectomy	14.182	47.01	35	27	77.1%
laparoscopic hernia repair	14.183		25	23	92.0%
laparoscopic Nissen fundoplication	14.186		9	9	100.0%
total			484	416	86.0%

Table 29. Orthopedic Surgery procedures at LDS Hospital, November 1996 to January 1997. For each procedure the table lists the corresponding PTXT code, the ICD9 code, number of cases done, number of cases with prophylaxis, and rate of prophylaxis expressed in percent.

Orthopedic Surgery Procedures	PTXT	ICD9	96 cases	96 proph	percent
ankle fusion	18.6/23.106	81.11	4	3	75.0%
repair of hip fracture	18.47	79.39	7	5	71.4%
Kuntshcner nailing (IM rodding)	18.48	79.15	6	5	83.3%
proximal tibia osteotomy	18.68	77.37	1	1	100.0%
total hip	18.75	81.51	49	49	100.0%
total hip - revision	18.77	81.53	18	18	100.0%
total knee	18.78	81.54	50	50	100.0%
triple arthrodesis	18.81	81.12	4	3	75.0%
ORIF femur	18.102	79.35	22	21	95.5%
ORIF tibia	18.108	79.36	26	9	34.6%
total knee - revision	18.211	81.55	7	7	100.0%
triple hip osteotomy	23.83	77.29	1	0	0.0%
total			195	171	87.7%

Table 30. Gynecologic Surgery procedures at LDS Hospital, November 1996 to January 1997. For each procedure the table lists the corresponding PTXT code, the ICD9 code, number of cases done, number of cases with prophylaxis, and rate of prophylaxis expressed in percent.

Gyne Surgery Procedures	PTXT	ICD9	96 cases	96 proph	percent
laparotomy, BSO, incidental appendectomy	15.9	66.51	2	0	0.0%
laparotomy, ovarian cystectomy	15.12	66.29	6	4	66.7%
Marshal Marchetti	15.3	59.5	6	3	50.0%
radical hysterectomy	15.33	68.6	1	1	100.0%
radical vulvectomy	15.34	71.5	4	3	75.0%
repair of cystocele and rectocele	15.35	70.51	3	0	0.0%
repair of cystocele and rectocele	15.36	70.5	4	3	75.0%
repair of rectocele	15.37	70.52	4	2	50.0%
total abdominal hysterectomy	15.39	68.4	87	77	88.5%
vaginal hysterectomy	15.43	68.59	50	33	66.0%
vaginal vault suspension, abdominally	15.47	70.77	3	3	100.0%
wedge resection of ovary	15.49	65.22	2	0	0.0%
plain vulvectomy	15.64	71.6	5	1	20.0%
bladder suspension	15.72	57.89	1	1	100.0%
laparoscopic assisted vaginal hysterectomy	15.101	68.51	27	21	77.8%
total			205	152	74.1%

Table 31. Urological Surgery procedures at LDS Hospital, November 1996 to January 1997. For each procedure the table lists the corresponding PTXT code, the ICD9 code, number of cases done, number of cases with prophylaxis, and rate of prophylaxis expressed in percent.

Urological Surgery Procedures	PTXT	ICD9	96 cases	96 proph	percent
iliac node dissection, I125 seeds	22.29	92.27	7	1	14.3%
nephrectomy	22.32	55.5	10	10	100.0%
open urethral suspension	22.34	59.7	5	3	60.0%
pyelolithotomy	22.41	55.11	1	0	0.0%
pyeloplasty	22.42	55.87	1	1	100.0%
radical cystectomy with ilio conduit	22.45	57.71	3	3	100.0%
retro-pubic prostatectomy	22.48	60.4	1	1	100.0%
uretero/ileo anastamoses	22.65	56.51	1	1	100.0%
ureterolithotomy	22.66	56.2	1	1	100.0%
vesico/vaginal fistula	22.83	57.84	1	1	100.0%
radical prostectomy, all types	22.91	60.5	33	33	100.0%
total			64	55	85.9%

Table 32. Summary of all 4 Divisions at LDS Hospital, November 1996 to January 1997. For each Division the table lists the number of cases done, number of cases with prophylaxis, and rate of prophylaxis expressed in percent.

Division	96 cases	96 proph	percent
General Surgery	484	416	86.0%
Orthopedic Surgery	195	171	87.7%
Gynecologic Surgery	205	152	74.1%
Urological Surgery	64	55	85.9%
total	948	794	83.8%

APPENDIX G

OR SCHEDULE WITH DVT PROPHYLAXIS REMINDER

LDS HOSPITAL OPERATING ROOM SCHEDULE for Wednesday 12/10/97 as of 12/12/97.12:47

OR		ROOM	EST TIME	AGE	PATIENT NAME	PROCEDURE	SURGEON	ANES
1.1	abx	DSCH	0733@	30M	[redacted]	L WRIST DIAG SCOPE/EXC GANGLION	1SWENSEN,LS	RHONDEAU,SM
1.2		DSCH	0949@	69F	[redacted]	EXC MASS R WRIST/DECOMP FCR TENDON	2SWENSEN,LS	RHONDEAU,SM
1.3		DSCH	1108@	45F	[redacted]	R CTR (SSEXT-FOR PAIN MGT)	3SWENSEN,LS	RHONDEAU,Req
1.4A		DSCH	1300@	24M	[redacted]	REM HARDWARE L FOREARM	4SWENSEN,LS	RHONDEAU/MAC
2.1	abx DVT	W306	0730@	67M	[redacted]	BIL TOTAL KNEE REPLACE (CAT 2)	BERTIN,KC	BELL,KG/SPN
2.2	abx DVT	W329	1115@	58M	[redacted]	R TOTAL HIP REPLACE (CAT 1)	BERTIN,KC	BELL,KG/SPN
2.3	abx DVT	W345	1400@	61M	[redacted]	R TOTAL HIP REPLACE (CAT 1)	BERTIN,KC	BELL,KG/SPN
2.4A		W321	1630@	46M	[redacted]	I&D, CLOSURE LT HIP	BERTIN,KC	BELL,KG
2.5A		W333	1921@	82M	[redacted]	HEMI- ARTHROPLASTY HIP	AFFLECK,GW	HOPSON,CT
2.6A		W335	2228@	29M	[redacted]	SYNTHES 7.3 CANNULATED SCREWS FOR LT HIP FX (CHICK TBL, C-ARM)	ANDERSON,JW	FISHER,EK
3.1	abx DVT	W353	0718@	78F	[redacted]	R TOTAL KNEE REPLACEMENT	SAMUELSON,KM	TOWNSEND/SPN
3.2	abx DVT	W341	0855@	49M	[redacted]	R TOTAL KNEE REPLACEMENT	SAMUELSON,KM	TOWNSEND/SPN
3.3	abx DVT	W349	1044@	57M	[redacted]	BIL TOTAL KNEE REPLACEMENT	SAMUELSON,KM	TOWNSEND/SPN
3.4	abx DVT	W350	1341@	79M	[redacted]	R TOTAL HIP REV (CS)	SAMUELSON,KM	TOWNSEND/SPN
3.5	abx DVT	W343	1617@	88F	[redacted]	REV R TOTAL KNEE (FLEX OSTEOTOMES)	LARCOM,PG	TOWNSEND,DW
3.6A		E604	2038@	66F	[redacted]	ORIF LT PATELLA OPEN FX. PULSA-VAC, LG. BONE HOLDERS	ANDERSON,JW	TOWNSEND,DW
4.1		DSCH	0740@	46F	[redacted]	R CTR	PETERSON,RG	JAYAPRAKASH,
4.2	abx	DSCH AM(0645)	0850@	44F	[redacted]	C5-6 DISC/FUSION/PLATE	PETERSON,RG	JAYAPRAKASH,
4.3		DSCH AM(0845)	1138@	38M	[redacted]	L5-S1 LAM/DISC	PETERSON,RG	JAYAPRAKASH,
4.4A	abx	W611	1330@	75M	[redacted]	DRAIN (L) CHRONIC SUBDURAL HEMATOMA	PETERSON,RG	JAYAPRAKASH,
5.1		DSCH	0744@	51F	[redacted]	REMOVE I-125 PLAQUE R EYE	WINWARD,KE	CHILD,BS
5.2		DSCH	0844@	13M	[redacted]	L VIT/AFE/MEMB/LASER/FRAG LENS	WINWARD,KE	CHILD,BS
5.3		DSCH	1114@	77F	[redacted]	L VIT	WINWARD,KE	CHILD,BS/MAC
5.4	abx	E607	1440@	21F	[redacted]	L1 BURST FX/C3-4 FX (EVOKE/CS/X-RAY TABLE) (6HR)	WARNER,SJ/PRICE,R	CHILD,BS
6.1		DSCH	0732@	23M	[redacted]	TONSILLECTOMY	MILLER,SK	RAO,S
6.2		DSCH	0844@	58F	[redacted]	FESS (POST LIVER TX)	MILLER,SK	RAO,S
6.3	DVT	DSCH AM(0830)	0959@	54F	[redacted]	THYROIDECTOMY	MILLER,SK	RAO,S
6.4		W743	1242@	72M	[redacted]	MICRO LARYNGOSCOPY/FAT INJECTION	MILLER,SK	RAO,S
7.1		DSCH	0738@	28F	[redacted]	SCREW REM R HIP (MINI C-ARM)	MORGAN,JM	MYERS,KJ
7.2		DSCH	0846@	18M	[redacted]	ORIF R 5TH METATARSAL (MINI C-ARM)	MORGAN,JM	MYERS,KJ
7.3		DSCH	1003@	15M	[redacted]	REP SYNDESMOSIS/DELTOID LIGAMENT R ANKLE (MINI C-ARM)	MORGAN,JM	MYERS,KJ
7.4		DSCH	1153@	38M	[redacted]	ORIF R ANKLE/LATERAL SIDE ONLY (MINI C-ARM)	MORGAN,JM	MYERS,KJ
8.1		DSCH	0741@	3M	[redacted]	EXC L THUMB GANGLION CYST	ANDERSON,JW	PETERSEN,RS
8.2		DSCH	0849@	15F	[redacted]	EXC L WRIST GANGLION CYST	ANDERSON,JW	PETERSEN/MAC
8.3	abx DVT	DSCH	0947@	14M	[redacted]	ORIF L TIBIAL TUBERCLE AVULSION (SYNTHES 4.5MM SCREW SET)	ANDERSON,JW	PETERSEN,RS
8.4		DSCH	1227@	24M	[redacted]	REM EXT FIXATOR/HARDWARE L WRIST (SYNTHES)	ANDERSON,JW	PETERSEN/MAC
8.5		DSCH	1344@	71F	[redacted]	EXC BCCA W/RECON L NOSE	3HUNTER,GR	FISHER,E/MAC
8.6		DSCH	1453@	29F	[redacted]	BIL BREAST REDUCTION	4HUNTER,GR	FISHER,EK
8.7		DSCH	1735@	50F	[redacted]	BIL BREAST REDUCTION	5HUNTER,GR	FISHER,EK
8.8A		OR09	2044@	78F	[redacted]	REMOVAL INFECTED KNEE PROSTHESIS	BERTIN,KC	FISHER,EK
9.1		DSCH	0757@	15F	[redacted]	LAPAROSCOPY	RASMUSSEN,EK	FISHER,EK
9.2	DVT	DSCH AM(0715)	0848@	42F	[redacted]	POST REP	RASMUSSEN,EK	FISHER,EK
9.3	abx DVT	W441 AM(0900)	1031@	46F	[redacted]	TAH/BSO/ABD LIPECTOMY	RASMUSSEN,/HUNTER	FISHER,EK
9.4A		DSCH	1344@	55F	[redacted]	CLOSED RED. PINNING LT. DISTAL RADIUS	HAMMON,DJ	PETERSEN,RS
10.1	abx DVT	E844 AM(0530)	0735@	68M	[redacted]	RAD PROSTATE	SORENSON,C/BOURNE	TIMMINS.,Req
10.2	abx DVT	E830 AM(0845)	1025@	60M	[redacted]	RAD PROSTATE	SORENSON,CW	TIMMINS,R
11.1		DSCH	0730@	21F	[redacted]	CO2 LASER VULVA	VOSS,SC	MCCOMAS,GB
11.2		DSCH	0913@	21F	[redacted]	CO2 LASER VULVA/VAGINA/ANUS	TOWNSEND,DE	MCCOMAS,GB
11.3	DVT	E640	1024@	81F	[redacted]	CYSTO/CATHS/SIGMOID/TAH/BSO/OMENTECTOMY/TUMOR DEBULK/NODES (ABC/CUSA)	TOWNSEND,DE	MCCOMAS,GB
12.1		DSCH	0811@	35F	[redacted]	LAP TUBAL LIG/HULKA CLIPS	2MACY,VL	MCALLIST,Req
12.2		DSCH	1227@	78F	[redacted]	HYSTEROSCOPY/D&C	3MACY,VL	MCALLISTER,R
12.3		DSCH	1016@	36F	[redacted]	HYSTEROSCOPY/D&C/LAPAROSCOPY/YAG LASER	4MACY,VL	MCALLISTER,R

APPENDIX H

POSTER FOR DVT PROPHYLAXIS STUDY

DVT
Prophylaxis Study

A new reminder now appears on the O.R. schedule for patients who receive DVT prophylaxis.

When the DVT notice appears, please make sure the patient:

a. received coumadin or heparin (total joint surgery patients), or

b. has TED stockings/SCD or Plexipulse boots before anesthesia.

If there are any questions, please call Dr. Robert Patterson at 321-5552.

APPENDIX I

CODE FOR PAL PROGRAM TO LIST PROCEDURES AND CHEMOPROPHYLAXIS

DATA2.RPATTE.DVTPRO5

```
1     ?NOPREPROESS
2     ?FREETEXT 800
3     SECTION DVT;
4     BEGIN
5     ?NOLIST
6     ?SOURCE "$SYSTEM HELP        LITERALS"
7     ?LIST
8     ! PAL Program written by Robert Patterson MD
9     ! with help from Kyle Johnson.  Compiled November 1997.
10
11    ! The purpose of this program is to determine which surgical
12    ! patients had DVT prophylaxis.  This program searches
13    ! a file of surgical patients who should have received DVT prophylaxis
14    ! which can consist of coumadin, heparin, enoxaparin, or mechanical
15    ! devices such as Sequential Compression Devices (SCD) or
16    ! Plexipulse boots.  The list of patients is then checked for PTXT codes
17    ! that indicate prophylaxis has been given.
18
19    ! This is how to compile the program
20    ! $SYSTEM.HELP.PAL/IN $DATA2.RPATTE.DVTPRO, OUT $S.#ROBERT,
21    ! PRI 100/$DATA2.RPATTE.DVTPRO
22
23    ! This is how to run the program
24    ! RUN $SYSTEM.HELP.DRIVER/IN $DATA.RPATTE.DVTPROo,
25    ! PRI 100/FLD;N
26    ! beginning of the main section
27
28    SECTION MAINE MAIN;
29    BEGIN
30    ! naming of the variables
31    VARIABLE ONE;
32    VARIABLE DATE;
33    VARIABLE P^NUM CHAR [4];
34    VARIABLE S^DATE CHAR [2];
35    VARIABLE FOUND;
36    VARIABLE DUMMY;
37    VARIABLE J^TIME;
38    VARIABLE PNAME CHAR [30];
39    VARIABLE PATIENT^NUM;
40    VARIABLE PROC^TEXT CHAR [60];
41    VARIABLE PROC^CODE CHAR [16];
42    VARIABLE OR^ROOM CHAR [1];
43
```

```
44    ! building a relationship for chemoprophylaxis
45    RELATION CHEMOPROPHYLAXIS
46    BEGIN
47     ITEM COUMADIN CODE (48 1 8 2 1 1 0 0 );
48     ITEM COUMATAB CODE (48 1 58 2 3 1 0 0);
49     ITEM HEPARIN^INJ CODE (48 1 8 2 3 2 0 0);
50     ITEM HEPARIN^SQ CODE (48 1 8 2 3 10 0 0);
51     ITEM ENOXAPARIN CODE (48 1 8 2 3 152 0 0);
52     ITEM ENOXAPTUBE CODE (48 1 81 2 21 48 0 0);
53     ITEM HEPARIN^VIAL CODE (48 1 58 2 4 1 0 0);
54    END;
56
57    ! nobody knows what this means, but everyone has it in their code
58    PAUSE OFF;
59    SETTIMER (0);
60
61
62    OPEN "ORF SURGERY SCHEDULE LOG" AS $FILES(18) READ^ONLY;
63    ! opening the files that contain the list of surgical patients
64    ! this is a logical file name - length is not important
65    OPEN "SFF MICROB SURGDVT" AS $FILES(19);
66
67    ! opening my output file
68    ! this is a physical file name and must be 24 characters long
69    OPEN "$DATA2 RPATTE ROBOUT          " AS $FILES(20);
70
71    ! selecting the date of surgery
72    WRITE FORMAT ("SEARCH PATINTS FOR WHAT DATE? mm/dd/yy")
73    INPUT^TIME (DUMMY $NOW);
74    S^DATE := WRITE $TIMETODATE (DUMMY) FORMAT (B2);
75    ! P^NUM := WRITE 00000001 FORMAT (B4);
76    ! KEYON $FILES(19) USING P^NUM APPROXIMATE;
77
78    ! the infamous keyon command
79    KEYON $FILES(18) USING S^DATE GENERIC;
80    WHILE RECORDIN $FILES(18) DO
81
82    ! the patient's name, date of surgery, and O.R. room are extracted
83    BEGIN          ! beginning of the loop
84     EXTRACT OR^ROOM      FIRST 7      LENGTH 1;
85     EXTRACT $PATIENT     FIRST 14     LENGTH 4;
86     EXTRACT PNAME        FIRST 18     LENGTH 30;
87     EXTRACT PROC^TEXT    FIRST 58     LENGTH 60;
88     EXTRACT PROC^CODE    FIRST 258    LENGTH 16;
89
```

```
90    FOUND := 0;
91    KEYON $FILES(19) USING S^DATE GENERIC ALTKEY "DT";
92    WHILE RECORDIN $FILES(19) DO BEGIN
93    EXTRACT PATIENT^NUM FIRST 0 LENGTH 4,
94          DATE FIRST 4 LENGTH 2;
95
96    IF $PATIENT = PATIENT^NUM AND $ASC(OR^ROOM) <> 23 AND
97    $ASC (0) END;
98    IF FOUND THEN
99     BEGIN
100   J^TIME := $DATETOTIME (DATE);
101   WRITE !FILES(20)! J^TIME, $PATIENT, PNAME, $ASC(OR^ROOM)
102   $ASC (PROC^CODE[5])
103   FORMAT (T(MTH,"/", DAY,"/", YR), " ", F9, " ", A20, " ", F2, " ",
104         A30," ", F2, " ", ".", F3, 1/);
105   ! checking for chemoprophylaxis using PTXT codes
106   BUILD CHEMOPROPHYLAXIS FROM $NOW BACK TO ($NOW-7 DAYS);
107   FOR ONE :=1 TO $COUNT (CHEMOPRPHYLAXIS) DO
108   BEGIN
109    WRITE !CHEMOPROPHYLAXIS [ONE]. COUMADIN! FORMAT (!P40!)
110   END;
111
112   ! writing the results to a file
113   IF $EXISTS (CHEMOPROPHYLAXIS) THEN
114   WRITE $FILES(20) J^TIME, $PATIENT, PNAME,$ASC(OR^ROOM)
115    $ASC(PROC^CODE[5])
116    FORMAT (T(MTH, ,"/", DAY,"/", YR), " ", F9, " ", A20, " ", F2, " ",
117         A30," ", F2, " ", ".", F3);
118
119   ELSE
120   WRITE $FILES(20) J^TIME, $PATIENT, PNAME,$ASC(OR^ROOM)
121    $ASC(PROC^CODE[5])
122    FORMAT (T(MTH, ,"/", DAY,"/", YR), " ", F9, " ", A20, " ", F2, " ",
123         A30," ", F2, " ", ".", F3);
124
125
126
127   END;  !IF FOUND
128   ! to avoid hogging the computer
129
130   SLEEP (50);
131
132   END;  !WHILE RECORDIN $FILES(18)
133
134
```

```
135    ! closing the output files
136    CLOSE $FILES(20);
137
138    ! closing the surgical patient files
139    CLOSE $FILES(19);
140    CLOSE %FILES(18);
141    END;  !MAIN
142    END;  !DVT
```

APPENDIX J

REPORT GENERATED BY PAL PROGRAM

FOR CHEMOPROPHYLAXIS

An example of the report which gathered data on anti-coagulation for surgery patients in the DVT prophylaxis study. The data is real; all patient names have been replaced in order to protect patient confidentiality. The first column is the date, the second is the encounter number, the third is the patient's name. The next column is the OR theater number. The Yes/No indicates whether or not the patient had chemoprophylaxis (anticoagulation). The next column has the text description of the operation. The last column has the PTXT procedure code for the operation.

January 29 1998

01/29/98 18272112 PATIENT, NAME 18 No EXPLORATORY LAPAROTOMY;ILEOSTO 14. 24
01/29/98 18271270 PATIENT, NAME 8 No LAP CHOLE W/GRAMS (C-ARM) 14.180
01/29/98 18269639 PATIENT, NAME 12 No LAP CHOLE W/GRAMS (C-ARM) SS E 14.180
01/29/98 18268979 PATIENT, NAME 18 Yes GBP 14. 78
01/29/98 18267500 PATIENT, NAME 6 No LAP CHOLE W/GRAMS (C-ARM) 14.180
01/29/98 18187385 PATIENT, NAME 11 No LAP CHOLE W/GRAMS (C-ARM) 14.180
01/29/98 18253922 PATIENT, NAME 11 No LAPAROSCOPIC COLECTOMY/CHOLE W 14.191
01/29/98 27925643 PATIENT, NAME 11 No LAP LYSIS ADHESIONS (BOWEL OBS 14.181
01/29/98 28216356 PATIENT, NAME 12 No LAPAROTOMY/ L COLECTOMY 14. 24
01/29/98 28198083 PATIENT, NAME 9 No TAH/BSO 15. 39
01/29/98 28196830 PATIENT, NAME 12 No EXC VAG MASS 15. 43
01/29/98 28195923 PATIENT, NAME 7 No OPEN CHOLE 14.114
01/29/98 18243543 PATIENT, NAME 18 Yes GBP/FUNDOPLICATION 14. 78
01/29/98 28157691 PATIENT, NAME 11 No LAP CHOLE W/GRAMS (C-ARM) 14.180
01/29/98 28166551 PATIENT, NAME 11 No LAP CHOLE / GRAMS 14.180
01/29/98 18211672 PATIENT, NAME 11 No LAP CHOLE W/GRAMS (C-ARM) 14.180
01/29/98 18206490 PATIENT, NAME 12 No POST REP/ENTEROCELE REP/VAG SU 15. 46
01/29/98 28119824 PATIENT, NAME 12 No TAH/BSO/MMK/SUPRA PUBIC CATH 15. 40
01/29/98 18047621 PATIENT, NAME 12 No EXC VAG MASS 15. 43

APPENDIX K

DAILY ENUMERATION OF CASES IN STUDY,

NOVEMBER 1997 TO JANUARY 1998.

Table 33. Results for November 1997.

Date	Cases	reminder	add-on	SCD	anti-coag	both	neither	no label	mislabel
3-Nov	27	24	3	22	5	0	0	0	0
4-Nov	19	15	4	19	0	0	0	0	0
5-Nov	17	15	3	14	3	0	0	0	1
6-Nov	15	14	0	14	0	1	0	1	0
7-Nov	15	18	0	12	3	0	0	0	3
8-Nov	3	3	0	3	0	0	0	0	0
9-Nov	1	0	1	1	0	0	0	0	0
10-Nov	31	30	1	21	10	0	0	1	1
11-Nov	14	11	3	13	1	0	0	0	0
12-Nov	16	16	1	10	6	0	0	0	1
13-Nov	10	9	1	10	0	0	0	0	0
14-Nov	23	19	4	19	2	2	0	0	0
15-Nov	2	1	1	2	0	0	0	0	0
16-Nov	0	0	0	0	0	0	0	0	0
17-Nov	28	26	4	16	10	0	2	0	2
18-Nov	21	21	1	21	0	0	0	0	1
19-Nov	15	15	1	7	8	0	0	0	1
20-Nov	13	12	0	13	0	0	0	1	0
21-Nov	21	21	1	16	2	3	0	0	1
22-Nov	1	0	1	1	0	0	0	0	0
23-Nov	4	1	3	3	0	1	0	0	0
24-Nov	22	23	2	19	3	0	0	0	3
25-Nov	14	8	6	13	1	0	0	0	0
26-Nov	4	1	3	4	0	0	0	0	0
27-Nov	1	0	1	0	1	0	0	0	0
28-Nov	8	8	0	8	0	0	0	0	0
29-Nov	1	0	1	1	0	0	0	0	0
30-Nov	4	3	1	3	1	0	0	0	0
Nov Total	350	314	47	285	56	7	2	3	14

Cases - number of eligible cases for that day
Reminder - number of cases which had the DVT reminder on the OR schedule
Add-on - number of cases added on, no DVT reminder on OR schedule
SCD - number of cases which received compression devices
Anti-coag - number of cases which received anticoagulation
Both - cases with both compression devices and anticoagulation
Neither - number of cases which received no DVT prophylaxis
No Label - scheduled eligible cases which did not have a DVT reminder
Mislabel - cases not in the study which incorrectly had a DVT reminder

Table 34. Results for December 1997.

Date	Cases	reminder	add-on	SCD	anti-coag	both	neither	no label	mislabel
1-Dec	27	26	1	19	8	0	0	0	0
2-Dec	11	10	1	11	0	0	0	0	0
3-Dec	13	12	1	8	4	1	0	0	0
4-Dec	19	14	5	17	2	0	0	0	0
5-Dec	14	14	1	13	0	1	0	0	1
6-Dec	1	1	0	1	0	0	0	0	0
7-Dec	1	0	1	1	0	0	0	0	0
8-Dec	28	27	1	19	7	2	0	0	0
9-Dec	20	19	3	16	0	4	0	0	2
10-Dec	19	18	3	9	9	1	0	0	2
11-Dec	15	16	1	13	0	2	0	0	2
12-Dec	16	13	3	13	0	3	0	1	1
13-Dec	4	1	3	4	0	0	0	0	0
14-Dec	1	0	1	1	0	0	0	0	0
15-Dec	32	33	2	28	4	0	0	0	3
16-Dec	13	10	2	11	0	1	1	1	0
17-Dec	10	10	1	7	3	0	0	0	1
18-Dec	20	18	3	17	2	1	0	0	1
19-Dec	21	24	1	16	2	3	0	0	4
20-Dec	3	3	0	3	0	0	0	0	0
21-Dec	0	0	0	0	0	0	0	0	0
22-Dec	18	18	1	17	1	0	0	0	1
23-Dec	8	9	0	7	1	0	0	0	1
24-Dec	6	4	3	5	1	0	0	0	1
25-Dec	1	2	0	0	0	0	1	0	1
26-Dec	8	4	3	4	3	1	0	1	0
27-Dec	5	1	4	5	0	0	0	0	0
28-Dec	1	1	0	0	0	1	0	0	0
29-Dec	29	29	1	22	6	1	0	1	2
30-Dec	14	12	3	13	1	0	0	0	1
31-Dec	10	10	1	8	1	1	0	0	1
Dec Total	388	359	50	308	55	23	2	4	25

Cases - number of eligible cases for that day
Reminder - number of cases which had the DVT reminder on the OR schedule
Add-on - number of cases added on, no DVT reminder on OR schedule
SCD - number of cases which received compression devices
Anti-coag - number of cases which received anticoagulation
Both - cases with both compression devices and anticoagulation
Neither - number of cases which received no DVT prophylaxis
No Label - scheduled eligible cases which did not have a DVT reminder
Mislabel - cases not in the study which incorrectly had a DVT reminder

Table 35. Results for January 1998.

Date	Cases	reminder	add-on	SCD	anti-coag	both	neither	no label	mislabel
1-Jan	2	1	1	2	0	0	0	0	0
2-Jan	7	6	2	4	1	2	0	0	1
3-Jan	3	1	3	3	0	0	0	0	1
4-Jan	4	2	2	3	1	0	0	0	0
5-Jan	20	19	2	14	6	0	0	0	1
6-Jan	8	6	2	5	3	0	0	0	0
7-Jan	15	13	1	6	8	1	0	1	0
8-Jan	18	20	0	17	0	1	0	0	2
9-Jan	22	21	2	17	3	2	0	0	1
10-Jan	3	1	2	3	0	0	0	0	0
11-Jan	1	0	1	1	0	0	0	0	0
12-Jan	31	28	5	18	12	1	0	0	2
13-Jan	17	10	6	15	2	0	0	1	0
14-Jan	21	20	4	12	9	0	0	0	3
15-Jan	15	13	3	12	0	3	0	0	1
16-Jan	14	18	0	13	0	1	0	0	4
17-Jan	3	1	3	2	0	1	0	0	1
18-Jan	1	0	1	1	0	0	0	0	0
19-Jan	29	28	2	23	4	2	0	1	2
20-Jan	12	12	1	11	1	0	0	0	1
21-Jan	21	24	2	10	10	0	1	0	5
22-Jan	10	8	2	7	1	1	1	0	0
23-Jan	16	14	1	15	1	0	0	1	0
24-Jan	1	0	1	1	0	0	0	0	0
25-Jan	2	0	2	2	0	0	0	0	0
26-Jan	17	20	1	12	4	1	0	0	4
27-Jan	16	17	0	14	2	0	0	1	2
28-Jan	19	16	4	12	6	1	0	0	1
29-Jan	19	19	2	18	0	0	1	1	3
30-Jan	18	16	4	16	1	1	0	0	2
31-Jan	3	0	3	2	0	0	1	0	0
Jan Total	388	354	65	291	75	18	4	6	37

Cases - number of eligible cases for that day
Reminder - number of cases which had the DVT reminder on the OR schedule
Add-on - number of cases added on, no DVT reminder on OR schedule
SCD - number of cases which received compression devices
Anti-coag - number of cases which received anticoagulation
Both - cases with both compression devices and anticoagulation
Neither - number of cases which received no DVT prophylaxis
No Label - scheduled eligible cases which did not have a DVT reminder
Mislabel - cases not in the study which incorrectly had a DVT reminder

Table 36. Combined results for November 1997 to January 1998.

	Cases	remind er	add-on	SCD	anti-coag	both	neither	no label	mislabel
Total for study	1126	1027	162	884	186	48	8	13	76

Cases - number of eligible cases for that day
Reminder - number of cases which had the DVT reminder on the OR schedule
Add-on - number of cases added on, no DVT reminder on OR schedule
SCD - number of cases which received compression devices
Anti-coag - number of cases which received anticoagulation
Both - cases with both compression devices and anticoagulation
Neither - number of cases which received no DVT prophylaxis
No Label - scheduled eligible cases which did not have a DVT reminder
Mislabel - cases not in the study which incorrectly had a DVT reminder

APPENDIX L

SUMMARY BY PROCEDURE OF CASES IN STUDY

Table 37. Number of cases and rate of prophylaxis by procedure for the study group in the Division of General Surgery.

General Surgery Procedure	97 cases	97 proph	percent
abdominal perineal resection	3	3	100.0%
anterior resection	4	4	100.0%
axillery node dissection	10	10	100.0%
bowel resection et al	42	42	100.0%
open cholecystectomy	6	6	100.0%
colectomy, right hemi	7	7	100.0%
exploratory laparotomy	78	77	98.7%
gastric resection	5	5	100.0%
incisional hernia repair	12	12	100.0%
mastectomy, uni,bi	10	10	100.0%
modified radical mastectomy	21	21	100.0%
neck dissection for removal of salivary gland	2	2	100.0%
Nissen fundoplication	3	3	100.0%
parathyroidectomy	6	6	100.0%
parotidectomy	2	2	100.0%
radical groin dissection	3	3	100.0%
radical neck dissection	4	4	100.0%
sigmoid resection	3	3	100.0%
splenectomy	5	5	100.0%
subtotal thyroidectomy	1	1	100.0%
thyroidectomy	18	18	100.0%
vagotomy	2	2	100.0%
ventral hernia repair	35	35	100.0%
gastric bypass	14	14	100.0%
cholecystojejunostomy	2	2	100.0%
adrenalectomy	2	2	100.0%
hemi-pelvectomy	1	1	100.0%
Whipple	2	2	100.0%
left colectomy	3	3	100.0%
gastric bypass	7	7	100.0%
pancreatectomy	5	5	100.0%
closure colostomy	6	6	100.0%
hepatectomy	8	8	100.0%
esophago-gastrectomy - abd approach	4	4	100.0%
spleno-renal shunt	2	2	100.0%
pancreatic debridement	6	6	100.0%
abdominal debridement	1	1	100.0%
laparoscopic cholecystectomy, possible open	168	168	100.0%
laparoscopic splenectomy	1	1	100.0%
laparoscopic appendectomy	39	39	100.0%
laparoscopic hernia repair	47	47	100.0%
laparoscopic Nissen fundoplication	23	23	100.0%
laparoscopic colon resection	4	4	100.0%
total for General Surgery	627	626	99.8%

Table 38. Number of cases and rate of prophylaxis by procedure for the study group in the Division of Orthopedic Surgery.

Orthopedic Surgery Procedure	97 cases	97 proph	percent
ankle fusion	11	11	100.0%
sliding nail / DHS hip pinning	18	16	88.9%
Kuntshcner nailing (IM rodding)	7	7	100.0%
Thompson/Austin-Moore hip	3	3	100.0%
total hip	65	65	100.0%
total hip - revision	12	12	100.0%
total knee	85	84	98.8%
triple arthrodesis	1	1	100.0%
ORIF femur	11	11	100.0%
ORIF acetabulum	4	4	100.0%
ORIF tibia	13	12	92.3%
ORIF - tibia plateau	1	1	100.0%
IM nailing tibia	2	2	100.0%
total knee - revision	2	2	100.0%
Thompson Austin Moore endoprosthesis	1	1	100.0%
total for Orthopedic Surgery	236	232	98.3%

Table 39. Number of cases and rate of prophylaxis by procedure for the study group in the Division of Gynecologic Surgery.

Procedure	97 cases	97 proph	percent
laparotomy, BSO, incidental appendectomy	5	5	100.0%
laparotomy, ovarian cystectomy	2	0	0.0%
rectocele repair	1	1	100.0%
Marshal Marchetti	9	9	100.0%
radical hysterectomy	2	2	100.0%
radical vulvectomy	2	2	100.0%
repair of cystocele	2	2	100.0%
repair of cystocele and rectocele	7	7	100.0%
total abdominal hysterectomy	88	88	100.0%
vaginal hysterectomy	55	54	98.2%
vaginal vault suspension, vaginally	2	2	100.0%
plain vulvectomy	2	2	100.0%
Burch urethropexy	5	5	100.0%
vaginal vault suspension	3	3	100.0%
laparoscopic assisted vaginal hysterectomy	30	30	100.0%
lymph node dissection	12	12	100.0%
total for Gynecologic Surgery	227	224	98.7%

Table 40. Number of cases and rate of prophylaxis by procedure for the study group in the Division of Urologic Surgery.

Procedure	97 cases	97 proph	percent
nephrectomy	5	5	100.0%
radical cystectomy with ilio conduit	2	2	100.0%
retro-pubic prostatectomy	4	4	100.0%
ureteroplasty	1	1	100.0%
radical prostectomy, all types	24	24	100.0%
pubo-vaginal sling	1	1	100.0%
total for Urologic Surgery	36	36	100.0%

Table 41. Number of cases and rate of prophylaxis by procedure for the study group for all 4 Divisions.

Division	97 cases	97 proph	percent
General Surgery	627	626	99.8%
Orthopedic Surgery	236	232	98.3%
Gynecologic Surgery	227	224	98.7%
Urologic Surgery	36	36	100%
Total	1126	1118	99.3%

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