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Effectiveness of Workflow Change for Improving the Timing of Prophylactic Antibiotics

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Abstract

Objective: Prophylactic antibiotics are effective in reducing surgical site infection, especially if administered with appropriate timing. However, the timing of administration in clinical practice is usually suboptimal. This study evaluated the effect of changing workflow to improve the timing and documentation of antibiotic administration.

Materials and Methods: In a 682-bed regional teaching hospital, the personnel in charge of prophylactic antibiotic administration were changed from ward nurses to operating room nurses and the time of antibiotic administration was recorded on the surgical nursing record starting on April 1, 2006. The effect of workflow change was measured by improvement in the timing of antibiotic administration after the intervention. Patient records were identified by a search of the hospital coding database. A case was defined by a principal or secondary procedure code for six types of surgeries: total hip replacement, total knee replacement, herniorrhaphy, thyroidectomy, hemorrhoidectomy and abdominal hysterectomy. Patients receiving therapeutic antibiotics because of documented preoperative infections were excluded from the study. Appropriate timing was defined as prophylactic antibiotics administered within 2 hours before incision. Patient outcome was assessed by the incidence of surgical site infections.

Results: During the study period from May 1 to October 31, 2006, 178 patients were enrolled in the study. These patients were compared with 160 patients who had surgery before the intervention period (May 1 to October 31, 2005). A statistically significant improvement in the appropriate timing of administering prophylactic antibiotics was noted between the two periods (41.8% to 78.9%; OR=5.199; $p<0.001$; 95% CI=3.213–8.413). The number of patients without documentation of timing of prophylaxis decreased significantly from 49.4% to 3.4% (OR=0.036; $p<0.001$; 95% CI=0.015–0.087).

Conclusion: The workflow change had a significant effect on improving the timing and documentation of prophylactic antibiotic administration. (*Tzu Chi Med J* 2009;21(4):310–316)

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1. Introduction

Surgical site infections (SSIs) can occur in the early days after surgery and prophylactic antibiotics reduce the postoperative infection rate dramatically (1). Classen et al demonstrated that the ideal interval for the delivery of prophylactic antibiotics is within 2 hours before incision, as administration after incision results in a four-fold increase in SSIs (2). However, despite this evidence, real clinical practice in the timing of prophylactic antibiotic administration is suboptimal. In 1996, a study of patients receiving hip replacement, abdominal aortic aneurysm repair, or large bowel resection in 44 hospitals in New York State, USA, demonstrated that only 63% of patients who received prophylactic antibiotics had received them within 2 hours before incision (3). Ten years later, Bratzler et al also reported that only 55.7% of Medicare patients undergoing major surgical procedures received prophylactic antibiotics within the appropriate time interval before incision in 2965 acute-care hospitals in the United States (4).

In National Taiwan University Hospital, Yun-Lin Branch, a 2004 retrospective audit revealed that prophylactic antibiotics were often used inappropriately. The most common problem was the timing of administration; only 7.5% patients were documented to have received prophylactic antibiotics within 2 hours before incision (unpublished data, Sung-Ching Pan, National Taiwan University Hospital, 2004). Our previous study reported significant improvement in the usage of prophylactic antibiotics, especially in the proper timing of administration, with the use of an antibiotic record form (5). After the use of a "prophylactic antibiotics record form" was implemented in April 2005, 54.9% of patients were documented as receiving prophylactic antibiotics within 2 hours before incision, which was an improvement from 2.6% in the pre-intervention period. However, further improvement can still be achieved.

There are several obstacles in the proper timing of antibiotic administration. Using a questionnaire, Tan et al reported that the barriers for proper timing included: (1) low priority; (2) inconvenience; (3) workflow; (4) organizational communication; and (5) role perception (6). Workflow and role perception were the dominant obstacles in their study. Thus, workflow involving the administration of prophylactic antibiotics was examined and redesigned after discussion with the Antibiotics Control Committee and the Operation Committee in our institution, with implementation in May 2005. The aim of this report was to evaluate the efficacy of the workflow changes on the proper timing and documentation of prophylactic antibiotic administration.

2. Materials and methods

2.1. Setting

This retrospective, epidemiological investigation was performed at the National Taiwan University Hospital Yun-Lin Branch, a 682-bed, university-affiliated, primary care teaching hospital.

2.2. Intervention

In our institution, prophylactic antibiotics were administered in the ward while the patient was on-call to the operating room (OR). However, operations were often delayed for many reasons; for example, the previous surgery was longer than expected, or the surgeon or anesthetist was not available. Because of this, prophylactic antibiotics were often given more than 2 hours before the operation. If the antibiotics could be administered within the OR, there would be less chance of delay. Thus, after discussion with the Antibiotics Control Committee and the Operation Committee in our institution, the personnel in charge of prophylactic antibiotic administration were changed from the ward nurses to the OR nurses. The workflow change was implemented in May 2006. Antibiotics were preordered and sent to the ward on the day of surgery and were brought to the OR with the patient. The ward nurse would give the antibiotics to the OR nurse as part of the patient hand-off procedure. The OR nurse was in charge of administering the antibiotics before induction and documenting it on the surgical nursing record.

The second intervention focused on documentation of the timing of prophylactic antibiotic administration. Although nursing personnel in the surgical department had been asked to fill out the prophylactic antibiotics record form (records included the

Prophylactic antibiotics administration record

	Antibiotic	Dose	Route	Time	Nurse
1st dose					
Supplemental dose					
Supplemental dose					

Fig. 1 — The stamp that is put on the surgical nursing record for documentation of prophylactic antibiotics administration.

antibiotics used, time of antibiotic administration, and treatment duration) in April 2005, the availability of the prophylactic antibiotics record form was suboptimal and 29% of patients had no documentation of administration (5). To improve documentation, we checked patient records and found that the surgical nursing record could be a useful tool. This record documented the time of important steps in the operation, such as when analgesia began and ended, the first incision, and surgical wound closure. Thus, after communication with the Antibiotics Control Committee and the Operation Committee, a stamp was used on the surgery nursing record to record when prophylactic antibiotics and specific antibiotics were given, including the first dose of prophylactic antibiotics and any supplementary doses if surgery was prolonged more than 3 hours (Fig. 1). The head of the OR nursing staff was responsible for making sure that the surgical nursing record was renewed with the stamp on it. The new administration and documentation procedures were implemented on May 1, 2006.

2.3. *Assessment of the effect*

Patient records were identified by a search of the hospital coding database during the post-intervention period from May 1 to October 31, 2006 (period 2). A comparison group was selected from May 1 to October 31, 2005 (period 1). A case was defined as a principal or secondary procedure code from the *International Classification of Diseases, Ninth Revision, Clinical Modification* (7) of total hip replacement (THR) (81.51), total knee replacement (TKR) (81.54), thyroidectomy (06.2–06.39), hemorrhoidectomy (49.46), herniorrhaphy (53.00–53.02, 53.29, 53.10–53.13), and abdominal hysterectomy (68.4). These procedures were selected because of the high volume of performance in our hospital and availability of consensus with regard to appropriate antimicrobial prophylaxis. Patients receiving therapeutic antibiotics because of documented preoperative infections were excluded from the study.

The process outcome measures included the proportion of patients who (1) received parenteral antimicrobial prophylaxis within 2 hours before surgical incision, (2) received a prophylactic antimicrobial agent longer than 2 hours before surgical incision or after surgical incision, (3) had no documentation of the time of prophylactic antibiotic administration, or (4) received no prophylactic antibiotics.

The patient outcome was assessed by the incidence of SSI. SSI was determined through hospital-wide surveillance by infection control nurses based on the National Nosocomial Infection surveillance system (8). SSI was identified for inhouse patients by a positive culture or clinical report. SSI was also identified for discharged patients by readmission with a positive culture or clinical report within 1 month of surgery without implants or within 1 year of surgery with implants. The overall SSI rate was defined as the number of all SSIs per 100 admission surgeries. The index case specific rates of SSI were defined as the number of SSIs among the six index surgery categories per 100 index surgeries.

2.4. *Data analysis*

Proportions were compared with the χ^2 test. If the number in any cell was>5, Fisher's exact test was used instead. A p value less than 0.05 was regarded as statistically significant. All analyses were performed using SAS version 8.2 (SAS Institute Inc., Cary, NC, USA).

3. Results

During the study period, the number of patients admitted to the surgical department and the whole hospital remained stationary at approximately 431 cases per month. A total of 160 cases were identified by procedure code from period 1 (May to October, 2005) and 178 from period 2 (May to October, 2006). Two cases (one anal abscess and one incarcerated hernia with abscess formation) in period 1 and three cases (one anal abscess and two cases of tubo-ovarian abscess) in period 2 were excluded from the study because of documented preoperative infection. The total number of included cases remained relatively constant in the two study

periods and the distribution among the different procedure categories was approximately the same (p=0.732, Fig. 2).

The proportion of patients with appropriate timing of prophylactic antibiotic administration, defined as parenteral antibiotics injected within 2 hours before incision, increased significantly from the pre-intervention period (41.8%, 66/158) to the post-intervention period (78.9%, 138/175) (OR=5.199; p<0.001; 95% CI=3.213–8.413). The proportion of patients with no documentation of the timing of prophylactic antibiotics significantly decreased from the pre-intervention period (49.4%, 78/158) to the post-intervention period (3.4%, 6/175) (OR=0.036; p< 0.001; 95% CI=0.015–0.087) (Table 1). There was a sustained improvement both in the appropriate timing and documentation of prophylactic antibiotics (Fig. 3).

Notably, there was variation in the appropriate timing of prophylactic antibiotic administration among different surgical categories in period 1. The orthopedic department had better timing of antibiotics administration (78.9%, 15/19 for TKR and 100%, 3/3 for THR) than all the other departments evaluated. No significant variation was noted in period 2 (Fig. 4).

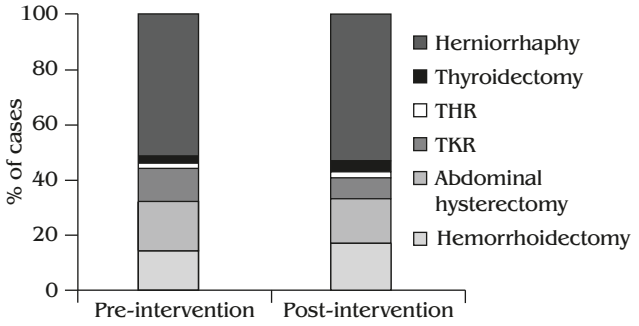

Fig. 2 — Comparison of the number of patients in each surgical category between the pre-intervention (May 2005 to October 2005) and post-intervention (May 2006 to October 2006) periods, p=0.732. THR=total hip replacement; TKR=total knee replacement.

Table 1 — Comparison between the pre-intervention and post-intervention periods for the timing of prophylactic antibiotics administration

Timing of antibiotics	*n* (%)		*p*
	Period 1*	Period 2†	
Appropriate‡	66 (41.8)	138 (78.9)	<0.001
Inappropriate§	12 (7.6)	25 (14.3)	0.056
No document	78 (49.4)	6 (3.4)	<0.001
No prophylactic antibiotics	2 (1.3)	6 (3.4)	0.22
Total	158 (100)	175 (100)	

*Period 1: pre-intervention period from May to October, 2005; †period 2: post-intervention period from May to October, 2006; ‡appropriate timing defined as prophylactic antibiotics administered within 2 hours before incision; §inappropriate timing defined as prophylactic antibiotics administered longer than 2 hours before incision or later than incision.

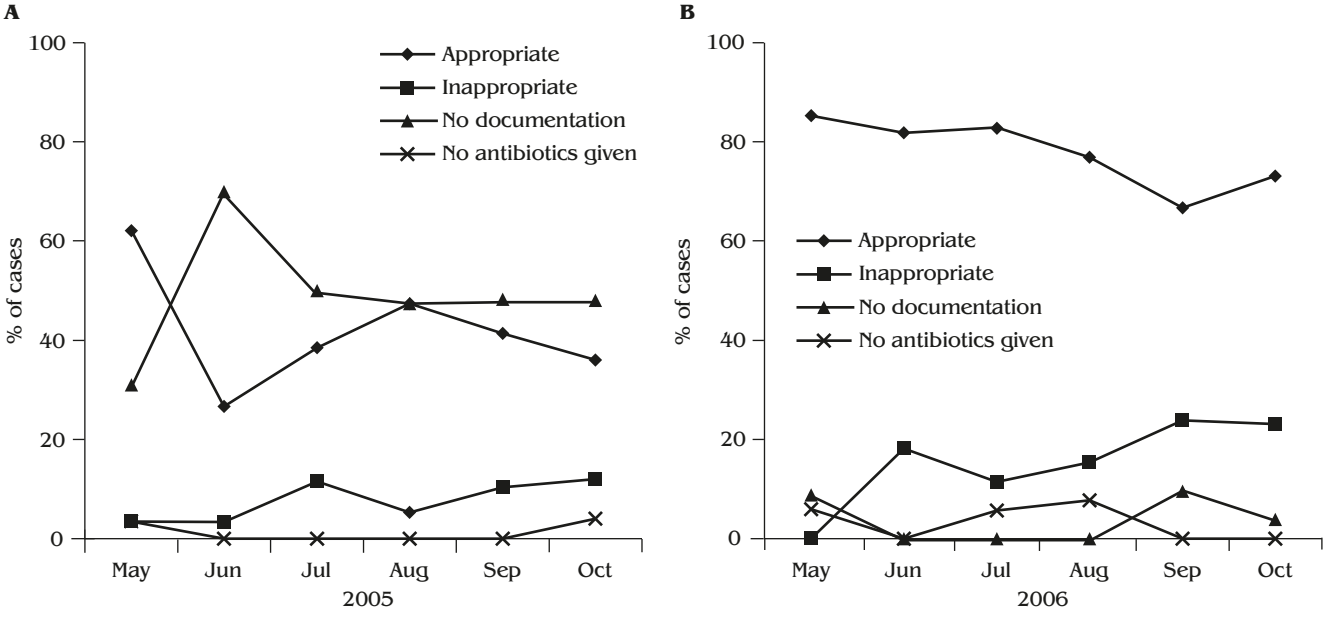

Fig. 3 — Timing of prophylactic antibiotics administration: (A) pre-intervention period; (B) post-intervention period. "Appropriate" is defined as prophylactic antibiotics administered within 2 hours before incision. "Inappropriate" is defined as prophylactic antibiotics administered longer than 2 hours before incision or after incision.

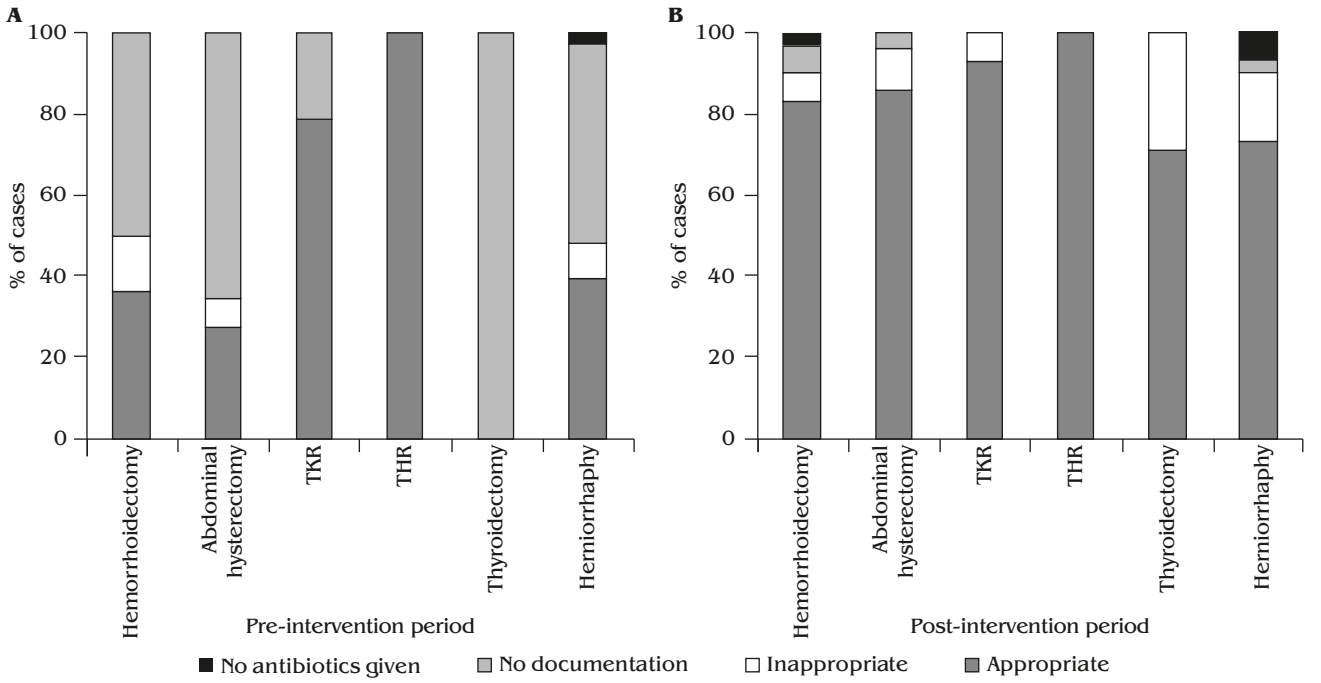

Fig. 4 — Timing of prophylactic antibiotics in the (A) pre-intervention (May 2005 to October 2005) and (B) post-intervention (May 2006 to October 2006) periods by surgical category. TKR=total knee replacement; THR=total hip replacement.

Table 2 — Incidence of SSI before and after the intervention

	Period 1*		Period 2†		*p*
	N	SSI, *n* (%)	*N*	SSI, *n* (%)	
Overall admission surgeries	2351	10 (0.43)	2827	10 (0.28)	0.48
Six index surgeries	158	0	175	0	NA

*Period 1: pre-intervention period from May to October, 2005; †period 2: post-intervention period from May to October, 2006. SSI=surgical site infection.

Before the implementation of the workflow change, the incidence of overall SSI in our institution was 0.43% (10/2351) in period 1. After institution of these interventions, the rate of overall SSI in period 2 was 0.28% (10/2827, p=0.479). For the six index surgical categories, related SSI rates were both 0% in the two periods (Table 2).

4. Discussion

This study demonstrated that workflow change can effectively improve the timing and documentation of prophylactic antibiotic administration. This involved changing the personnel in charge of antibiotic administration from the ward nurses to the OR nurses, and the use of the surgical nursing records for documentation by the OR nurse who injects the antibiotics.

Even though the concept of prophylactic antibiotics was developed after a series of animal studies in the 1950s [9] and clinical evidence in the 1960s [10–12], real practice in the clinical setting is suboptimal, as revealed by many nationwide surveillance programs [4,13,14]. Problems include inappropriate timing, antibiotic selection, and prolonged antibiotics usage. The timing of prophylactic antibiotics is the most critical step in preventing SSI, while the selection and prolonged usage of prophylactic antibiotics may lead to unnecessary medical expenses and antibiotic resistance. Thus, the timing of administration was the main focus of improvement in our institution.

Many studies have used local guidelines and education programs to improve the timing of prophylactic antibiotic administration but the results were suboptimal. Schell et al reported on the implementation of guidelines focused on the timing and duration of prophylactic antibiotic therapy in non-emergency bowel surgery [15], and the percentage of patients who received parenteral prophylactic antibiotics within 1 hour of incision increased significantly. However, substantial improvement was still needed as only 53% of patients received antibiotics within the appropriate time in the post-intervention period. A similar finding was noted by van Kasteren et al [16]. After the implementation of national clinical practice guidelines, there was only a trend of improvement in the timing of prophylaxis

while there were significant improvements in the treatment duration and choice of antibiotics.

Why don't physicians follow clinical practice guidelines? Cabana et al demonstrated that barriers to physician adherence to practice guidelines included the knowledge level, attitude level and behavior level (17). Therefore, even though surgeons may receive information on prophylactic antibiotic guidelines and agree with the guidelines, other external factors may limit implementation, such as lack of time and organizational constraints. The workflow involves orders by the surgeons, pharmacy arrangements, and the person responsible for administration, which may not be mentioned in detail in the guidelines. Thus, in addition to promoting the prophylactic antibiotic guidelines available in Taiwan since 2004 (18), workflow change was our main focus for resolving the problem of poor timing of prophylactic antibiotics.

Before this intervention, we found that the orthopedic department had better performance in the timing of prophylaxis (THR and TKR). Analysis of the workflow in the orthopedic department showed that the antibiotics were brought to the OR for orthopedic surgeries and given under the order of the surgeons before incision. The OR nurses recorded the time of injection on a blank space on the surgical nursing records. Thus, we changed the location where prophylactic antibiotics were administered from the ward to the OR.

In some studies, administration of antibiotics in the preoperative admission area was eliminated and the role of anesthetists in the administering of antibiotics was emphasized, resulting in improvement in the timing (19–21). We also demonstrated that the OR is a proper location for prophylactic antibiotics administration since the "on-call" infusion in the ward is easily compromised by delays in transport or schedule changes. The timing of prophylaxis can be improved regardless of whether OR nurses or anesthetists administer the antibiotics.

The second focus of this study was documentation. Bull et al found that timing of prophylaxis could not be assessed in a high percentage of procedures because of poor documentation (14). Prado et al reported using a perioperative prophylaxis protocol to improve the usage of prophylactic antibiotics and found the effect on timing was difficult to compare since the documentation rate was only 55.2% and 73.9% in the pre- and post-intervention periods, respectively (22). Given that timing is the determining step in preventing SSI, documentation should be emphasized more and action taken to enforce it. Further audit would then be possible to ensure the effect of any quality improvement program.

In our previous study, a prophylactic antibiotics record form was used by ward nurses to record the antibiotics used, the time they were given and the treatment duration (5). However, the compliance rate was suboptimal. After analysis by the Antibiotics Control Committee, it was decided not to add new forms because of reluctance and poor compliance. The surgical nursing record was used to record the timing of prophylactic antibiotics and the OR nurse who injects the antibiotics is responsible for recording it. With this method, better documentation was achieved, with only 3.4% patients missing documentation on the time of administration after intervention compared with 49.4% in the pre-intervention period. After the workflow change, the effect on the timing and documentation of prophylactic antibiotics was sustained (Fig. 3). In November 2006, the Operation Committee added a "Prophylactic Antibiotics Administration Record" permanently to the surgical nursing record instead of using a stamp.

We also compared patient outcomes in the incidence of SSI. No significant change was noted in the incidence of overall SSI in our institution. However, since the SSI rate in clean and clean-contaminated operative wounds is usually low and the SSI rates of the six index surgery categories were 0% in both the pre-intervention and post-intervention periods, the potential effect of proper timing of prophylactic antibiotics was difficult to demonstrate.

There were some limitations in this study. First, we did not include all clean and clean-contaminated procedures. However, since we included the five major surgical departments in our institution, orthopedics, gynecology, general surgery, urology and otolaryngology, these procedures were representative of the surgical procedures in our hospital. A second limitation was that we did not perform post-discharge surveillance for SSI, so the incidence of SSI in our institution may have been underestimated. However, this condition did not change between the pre-intervention and post-intervention periods, so the effect was homogeneous in both periods.

In conclusion, shifting the location of prophylactic antibiotic administration from the ward to the OR and having the OR nurse who injected the antibiotics record the time on the surgical nursing record improved the timing and documentation of prophylactic antibiotic administration. Thus, work flow change can effectively bring available knowledge into practice.

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