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original article

Effectiveness of a preventive bundle of measures for reducing surgical site infections in patients undergoing elective orthopedic procedures in a Hellenic Air Force Hospital

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SUMMARY: **Effectiveness of a preventive bundle of measures for reducing surgical site infections in patients undergoing elective orthopedic procedures in a Hellenic Air Force Hospital.**

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Background. *Bundles of preventive measures may improve patient outcomes. The aim of this study is to investigate if a surgical site infections (SSIs) preventive bundle in orthopedic surgery patients can result in reduction of such infections, hospitalization length and cost.*

Methods. *The present is a retrospective cohort study. A total of 1299 patients was admitted to hospital for an elective orthopedic procedure during 2012-2015. The patients were subjected to either an integrated three-stage SSIs preventive protocol or standard preventive measures. The two groups were compared for incidence of SSIs, median hospitalization length and median cost.*

Results. *The incidence of SSIs was lower in the new-protocol group, when compared to the old protocol one (p=0.102). Median (md) hospitalization length was significantly lower in the new protocol group (md = 2) compared to "old-protocol" group (md= 5) [U = 280520, p<0.001]. Regarding arthroscopies, the median cost in the new protocol patients (md= 1500) was significantly lower compared to "old-protocol" patients (md= 1585) [(U= 112660), p < 0.001]. Knee arthroplasties' median costs did not differ (both mds= 4400, U = 2002, p > 0.05). For hip arthroplasties, the new protocol's patient median cost (md= 3000) was significantly lower than that of "old-protocol" (md = 4000) [U = 19680, p < 0.001].*

Conclusions. *The use of a bundle of measures for the prevention of SSIs in a hospital's orthopedic operations proved effective, since it resulted in substantial decrease of SSIs, statistically significant decreased hospitalization length, as well as cost.*

KEY WORDS: Orthopaedic surgical infections - Surgical site infections - Infections after arthroplasty.

Introduction

Bundle of measures or medical protocols are sets of evidence-based practices that, when implemented collectively, improve the reliability of their delivery and improve patient outcomes. In order for bundle implementation to be successful, each element of the bundle must be implemented collectively with complete consistency to achieve the most favorable outcomes ("all or none" approach) (1). The implementation of such bundles has been performed, among others, for the decrease of surgery site infections (SSIs) which are the third most common nosocomial infection type (2). These infections frequently lead to increased morbidity and length of patients' hospitalization and thus increased health costs (3, 4).

Regarding orthopedic procedures, SSIs preventive protocols are of paramount importance especially in cases where implants are used, such as in knee or hip arthroplasties (5). Such bundles or protocols have led to lower rates of SSIs and health costs in orthopedic surgeries (5).

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The present is a retrospective study, aiming to investigate whether a three stage SSIs preventive bundle of measures in elective orthopedic procedures, is associated with decreased SSIs, health care costs and in-hospital stay.

Patients and methods

Study design and protocol

The present was a retrospective cohort study that took place at "251" Hellenic Airforce General Hospital of Athens, Greece. Data were collected, from a prospectively maintaining database, regarding patients undergoing either knee arthroscopy or knee or hip arthroplasty, from January 2012 to December 2015. The study was divided in two periods. During the first period (January 2012 - December 2013), the patients were subjected to the standard SSIs preventive measures, whereas during the second study period (January 2014 - December 2015) a new integrated bundle of measures for prevention of SSIs was applied. The adopted protocol (Table 1) was designed based on most recent guidelines for the prevention of SSIs (6-11). Patients were followed-up for one year and cases of SSIs and re-hospitalizations were recorded.

More specifically, the differences in the SSIs preventive bundle of measures made in the second study period in the pre-operative stage were: patient evaluation 10 days prior to the operation and management of major SSIs risk factors, such as diabetes and nutrition, the whole body chlorhexidine bath (the night before operation and in the morning of the operation day), the preparation of surgical area with electric shaves only the night before the procedure, the administration of nasal mupirocin regardless of MRSA carriage status (start 1 day before and continue for 5 days post-operatively) and the minimization of in-hospital stay (<12 hours). Intraoperatively, following skin antisepsis with iodopovidone, the application of ethyl-alcohol or gluconic chlorhexidine was added as part of the protocol and the use of flash sterilization was prohibited, with the exception of an urgency. Furthermore, a series of educational courses were performed for nurses, as well as doctors, for the strict adherence of all other preventive measures that were also performed prior to the second study period, such as the limitation of movement of surgical stuff intraoperatively, the closed doors of the operating room and the postoperative manipulation of the surgical wound with aseptic techniques. To ensure adherence of this bundle of measures a series of random audits by the operating rooms head nurse were performed. Details of the bundle of SSIs preventive measures are provided in Table 1.

Study population

The "251" Hellenic Airforce General Hospital is a 400-bed tertiary health care institution in Athens, serving mainly urban and suburban population (both military personnel and citizens). A total of 1299 consecutive patients was admitted to Orthopedic Departments for knee arthroscopy or knee/hip arthroplasty during the study period (2012-2015). The patients were divided in two groups: "old-protocol" group (standard of care preparation; 2012-2013) and new-protocol group (preparation with the original protocol; 2014-2015).

Definitions

Surgical site infections (SSIs) are defined as infections occurring up to 30 days following surgery (or up to one year following surgery in patients receiving implants) and affecting either the incision or deep tissue at the operation site. SSI refers to three types of infection: superficial incisional, deep incisional and organ or space infection. Superficial incisional affects the skin and subcutaneous tissue, while deep incisional affects the fascial and muscle layers. Organ or space infection involves any region other than the incision that is manipulated during the procedure (12).

Continuous SSI surveillance following elective orthopedic procedures was already established in the everyday clinical practice of our healthcare institution. Surveillance was undertaken by infection control nurses through direct patient contact, as well as hospital electronic information systems.

Statistical analysis

The data collection was performed by two investigators and consisted of information about age (years), gender (female, male), grade (military, retired-military, citizen), type of operation (knee arthroscopy, knee arthroplasty, hip arthroplasty), new-protocol implementation (no, yes) and hospi-

TABLE 1 - PROTOCOL FOR PREVENTION OF SSIS. THE ADDITIONS IN THE NEW-PROTOCOL GROUP ARE MARKED WITH AN ASTERISK (*).

Pre-operative stage
- Clinical examination at least 10 days preoperatively*
- Management of risk factors for SSIs (e.g. smoking cessation, hyperglycemia, malnutrition)*
- Minimization of pre-operation in-hospital stay <12 hours*
- Whole body chlorhexidine bath (night before operation and morning of the operation day)*
- Preparation of surgical site only with electric devices, the night before procedure
- Hair self-removal at the surgical site by the patient is not permitted, at least 7 days before operation*
- Administration of nasal mupirocin regardless of MRSA carriage status (start 1 day before and continue for 4 days post-operatively)*
- IV antimicrobial administration ends 30 min. pre-operatively (the type of the antimicrobial agents did not change)

Intra-operative stage
- Skin antisepsis with iodine povidone followed by application of 70% ethyl-alcohol or application solution 2% gluconic chlorhexidine and 70% isopropyl alcohol*
- Closed doors of operation room at all times
- Limitation in movements of surgical stuff in the surgical theater
- Use of flash sterilization cycle, only when there is urgency*
- Use of 2 pairs of sterilized gloves by every member of surgical staff
- Maintenance of normal body temperature of the patient

Post-operative stage
- Coverage of surgical wound with sterilized compress for 24 - 48 hours
- Manipulation of surgical wound with aseptic techniques
- Alertness for early identification of signs and symptoms of SSI

talization length (days). Additionally, one year following each procedure, information regarding SSIs (no, yes), re-hospitalization (no, yes) and re-operation (no, yes) were also collected.

Data were analyzed with the ''Microsoft Open R'' statistical software, version 3.3.2. A Mann-Whitney test was performed to compare the medians of continuous variables between the two groups. A chi-square test was performed to compare categorical variables between the two groups. Finally, a simple logistic regression analysis was performed to identify the factors associated with SSIs. Statistical significance was set at the level in which $p < 0.05$.

Cost measurement

The cost for each patient was derived upon the Hellenic DRG (diagnosis related group) reimbursement system, plus the charge for exceeding days of hospital stay.

Ethical considerations

The study was approved by the scientific and bioethics committee.

Results

Demographic data

Demographics of the studied population are presented in Table 2. A total of 1299 patients (females = 516) was enrolled in the study. The patients' median age was 55 (range = 14-98). Of all patients, 740 (females = 283) were included in the first study period (old-protocol was implemented; period: 2012-2013), while 559 (females=236) were included in the second study period (the new-protocol described in Table 1 was implemented; period: 2014-2015).

The "old-protocol" group consisted of 238 (32%) military, 65 (9%) retired- military and 437 (59%) citizens. The respective patients in the "new-protocol" group were 238 (43%), 68 (12%) and 253 (45%). The "old-protocol" group consisted of 438 (59%) knee arthroscopies, 140 (19%) knee arthroplasties and 162 (22%) hip arthroplasties. The respective patients in the "new-protocol" group were 349 (62%), 26 (5%), 184 (33%).

Main clinical outcomes

Table 3 highlights the main clinical outcomes. The

TABLE 2 - DEMOGRAPHIC CHARACTERISTICS OF THE PATIENTS.

Patients	**"Old-protocol" group**	**"New-protocol" group**
N	740	559
Age (md, range)	54.5 (14 - 98)	56 (16 -95)
Women (n, %)	(283, 38%)	(236, 42%)
Grade (n, %)		
Military	(238, 32%)	(238, 43%)
Retired-military	(65, 9%)	(68, 12%)
Citizen	(437, 59%)	(253, 45%)
Operation (n, %)		
Knee arthroscopy	(438, 59%)	(349, 62%)
Knee arthroplasty	(140, 19%)	(26, 5%)
Hip arthroplasty	(162, 22%)	(184, 33%)

TABLE 3 - BASIC CLINICAL OUTCOMES.

Outcome	**"Old-protocol" group**	**"New-protocol" group**	**X^2 (df)**	**p - value**
SSI cases (n, %)	13 (1.8%)	4 (0.7%)	2.67 (1)	0.102
Re - hospitalization (n, %)	10 (1.4%)	4 (0.8%)	0.98 (1)	0.322
Outcome	**"Old- protocol" group**	**"New-protocol" group**	**Mann Witney test**	**p - value**
Days of hospitalization (md, range)	5 (1-53)	2 (1-73)	U = 280520	< 0.001*

**statistically significant*
SSI = surgical site infection, md = median

incidence of SSIs was found to be lower in the "new-protocol" group (SSIs rate= 0.8%), when compared to the old one [SSIs rate=1.7%]; [χ^2 (df) = 2.67 (1), p = 0.102]. A decrease in SSIs rates of 53% was noted after the implementation of the bundle of measures. Hospitalization length in days did not differ statistically between groups [χ^2 (df) = 0.98 (1), p > 0.05]. However, median length of hospitalization days after procedure was significantly lower in the "new-protocol" group (md=2) in comparison to the "old-protocol" group (md=5), [U = 280520, p<0.001].

Regarding the variables age, gender, grade, new-protocol/old-protocol and type of operation, only operation type was associated with higher possibility for SSI. Specifically, the odds for SSI in a patient with knee arthroplasty was 5.9 times higher than that of knee arthroscopy (the reference group) [p = 0.004, (95% 1.75 to 20.57)]. Regarding hip operation the odds for SSI was not significantly higher than knee arthroscopy group (reference group) [OR=2.8, p = 0.095, (95% 0.83 to 9.63)].

Economic outcomes

The economic outcomes are shown in Table 4. Regarding arthroscopies, the median cost in "new-protocol" patients (md = 1500) was significantly lower than in "old-protocol" patients (md = 1585) [(U = 112660), p < 0.001]. For knee arthroplasties, the median cost in "new-protocol" was not different from that of "old-protocol" (both mds = 4400, U = 2002, p > 0.05). For hip arthroplasties, the "new-protocol's" patient median cost (md = 3000) was significantly lower than that of "old-protocol" (md = 4000) [U = 19680, p < 0.001].

TABLE 4 - COST COMPARISONS.

Cost in euros per operation type based on Diagnosis per Group (DRG) (md, range)	"Old-protocol" group	"New-protocol" group	Mann Witney test	p - value
Arthroscopy	1585 (500- 2690)	1500 (1500-7535)	U = 112660	< 0.001*
Knee arthroplasty	4400 (4000-6100)	4400 (4000-5503)	U =2002	0.395
Hip arthroplasty	4000 (3000-7230)	3000 (1500-7825)	U = 19680	< 0.001*

**statistically significant*
md = median

Discussion

The adoption and systematic use of medical protocols is a relatively new concept (13). Medical protocols are evidence based standardized processes that are used for the minimization of malpractice, medical complications, as well as for the decrease of medical costs (13). They are useful tools that help with decision making and improve the quality of everyday clinical practice (1, 14-16).

In many countries, such as Greece, medical protocols are not yet widely used (17, 18). The main difficulty is that there is sometimes resistance in the acceptance of a new medical protocol by the medical or nursery staff, as well as difficulty in compliance measurement (19). Additionally, changes based on current evidence are needed whenever a protocol becomes obsolete (20, 21).

The present protocol was designed based on the concept that simple and low cost measures may decrease the SSIs following elective orthopedic procedures (5). Consequently, decline in the rate of SSIs is economically advantageous for health care systems, since re-admissions are avoided and hospital stay is decreased (22-25). In this retrospective study, the implementation of a general three-stage SSIs preventive protocol for the prevention of SSIs in three common elective orthopedic surgeries resulted in substantial decrease of the SSIs. More specifically, a decrease in SSIs rates of 53% was noted after the implementation of the bundle of measures. A statistically significant decrease of the in-hospital stay in the "new-protocol" group when compared to the "old-protocol" group was also observed. This could be attributed to the fact that the "new-protocol" was composed of general health measures such as management of major risk factors, at least one week before the procedure. These factors are not directly related to the surgical site care itself but are rather more systematic (e.g. diabetes, smoking, nutrition) and are likely associated with a greater SSI risk (29). Therefore, a medical protocol can have multiple benefits for patients and ultimately for health care services. Our results, regarding lower SSIs rates, in hospital stay and costs after the implementation of this bundle of measures are in compliance with similar studies, testing such SSIs preventive bundles of care in vascular, general and colorectal surgery (26, 27).

SSIs are an important part of a hospital's acquired infections (28). In addition, a significant part of the hospital's costs is due to SSIs (29). The increased cost due to SSIs is partially because of the increased hospitalization length observed in such cases (29). Therefore, except from decrease in morbidity and mortality, such a protocol could economically benefit a health care system (24). In the present study, for two major orthopedic procedures, knee arthroscopy and hip arthroplasty there was a statistically significant reduction of 85 and 1000 euros respectively per case, after the protocol application. Re-hospitalization rates did not differ between the two groups, therefore the economic save in the protocol groups could be mainly attributed to the decreased length of hospitalization.

The main limitation of the present study is that it includes a single center and that there was no parameter evaluating the adherence of the staff to this bundle of measures. Furthermore, it should be considered that SSIs may affect the quality of patient's life (30). The quality of life in patients with SSIs is measured with psychometric tests and is often an

overlooked topic (30). Quality of life was not assessed which represents also another limitation of the study. However, it is clear that is reversely associated with increased hospitalization. Thus, it is possible that quality of life was improved in the studied patients since there was a significant reduction in hospitalization length with the implementation use of this SSIs preventive bundle of measures.

Conclusions

Medical protocols are useful tools in health care and contain specific and repeatable guidelines. Education on such protocols and their acceptance by all involved medical and nursery personnel can make their application easier and result in beneficial health and economic outcomes. The use of a SSIs preventive protocol in the orthopedic department of our hospital resulted in a decrease of the hospitalization length and cost, after three elective orthopedic procedures. Additionally, a substantial decrease in SSIs was also observed. Further multi-center studies should be conducted in order to show if there are additional benefits from such protocols.

Conflict of interest

The Authors declare that there is no conflict of interest.

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Authors' contributions

GK, KIA, CK FS for the literature search and analysis, and manuscript writing. DH, CK, IB for the final manuscript revision. All Authors read and approved the final manuscript.

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