CE

1.5 ANCC Contact Hours

Enhanced Recovery After Surgery for Hip and Knee Replacements

David P. Gwynne-Jones ▼ Ginny Martin ▼ Chris Crane

BACKGROUND: Enhanced recovery after surgery (ERAS) programs or hip and knee replacements have had a significant effect on streamlining patient care with shorter stays, no increase in complications, and improved outcomes including reduced mortality.

PURPOSE: To compare outcomes following the introduction of an ERAS program for hip and knee replacements developed at our institution with a historical cohort of patients.

METHODS: ERAS protocols were developed at our institution for patients undergoing hip and knee joint replacements. Key aspects were changes in preadmission, a new education session, improved management of perioperative anemia, standardized anesthetic guidelines, day of surgery mobilization, and improved discharge planning. The results of the first 18 months (528 consecutive patients) were compared with those of a historical cohort of 507 patients from the 18 months prior to their introduction.

RESULTS: In the ERAS group, the mean age was 68.3 years for patients who underwent hip replacement and 70.4 years for patients who underwent knee replacement. Thirty-two percent of patients were ASA (American Society of Anesthesiologists) Grades III and IV. The average preoperative Oxford score was 11. The average length of stay (ALOS) fell from 5.6 to 4.3 days for patients who underwent hip replacement and from 5.7 to 4.8 days for patients who underwent knee replacement ($p < .001$). Ninety-six percent of patients were discharged home. The 30-day readmission rate increased from 3.2% to 5.5% ($p = .065$). Six-month Oxford knee scores were higher in the ERAS group (39.8 vs. 36.3, $p = .03$). There was no increase in mortality or early revision rate.

CONCLUSIONS: Substantial reductions in ALOS can be gained with the introduction of ERAS protocols, with high patient satisfaction and no increase in complications in a consecutive unselected group of public hospital patients. This requires a multidisciplinary approach and a strong clinical input.

Background

Enhanced recovery after surgery (ERAS) programs, also known as enhanced recovery programs (ERPs), fast track, or rapid recovery, are based on the work of Henrik Kehlet in colorectal surgery (Kehlet, 1997). In recent years, there has been considerable interest in their introduction in orthopaedic surgery, especially in hip and knee replacements (Ibrahim, Twaij, Giebaly, Nizam, & Haddad, 2013; Kehlet & Thienpont, 2013). Programs are designed to prepare patients for, and reduce the total impact of, surgery, helping them recover more quickly. These programs include preoperative information and optimization of comorbidities, anesthetic and postoperative analgesia, surgical technique, perioperative blood management, early mobilization, rehabilitation, and discharge planning (Kehlet & Thienpoint, 2013). Such programs take a whole-system, evidence-based, multidisciplinary approach (Ibrahim et al., 2013; Kehlet & Thienpoint, 2013). In orthopaedics, they may reduce mortality, average length of stay (ALOS), and perioperative complications without an increase in complication or readmission rates (Kearney, Jennrich, Lyons, Robinson, & Berger, 2011; Malviya et al., 2011; McDonald, Siegmeth, Deakin, Kinninmonth, & Scott, 2012; Wainwright & Middleton, 2010). As there are approximately six times more elective hip and knee replacements performed per year in the United Kingdom than colorectal procedures, the potential benefits may be greater (Wainwright & Middleton, 2010).

Despite the success of ERAS programs, there have been few published results in Australasia (Keane et al., 2012). We developed and implemented ERAS protocols as part of a wider program—the Orthopaedic Patient Pathway funded by the Ministry of Health, under the Elective Services Productivity and Workforce Program. The purpose of this article is to describe the development, implementation, and results of the first 18 months of the program in our public hospital. The first 528 patients undergoing primary hip or knee replacement following the introduction of the ERAS program were

David P. Gwynne-Jones, MA, FRACS (Orth), Associate Professor, Department of Surgical Sciences, Dunedin School of Medicine, University of Otago, Dunedin, New Zealand; and Consultant Orthopaedic Surgeon, Dunedin Public Hospital, Southern District Health Board Dunedin, New Zealand.

Ginny Martin, PGDip, RN, Registered Nurse, Dunedin Public Hospital, Southern District Health Board Dunedin, New Zealand.

Chris Crane, PGDip (Public Health), BSc, Program Manager, Southern District Health Board Dunedin, New Zealand.

The authors and planners have disclosed no potential conflicts of interest, financial or otherwise.

DOI: 10.1097/NOR.0000000000000351

compared with a historical cohort from the 18-month period immediately prior to their introduction.

Methods

Our institution is the main hospital for a population of 200,000, covering a sparsely populated area of 32,000 square kilometers. There are 10 orthopaedic surgeons and one arthroplasty fellow who perform approximately 400 hip and knee arthroplasties including revision surgery per year. Elective patients are admitted to a single orthopaedic elective ward (20–24 beds). In addition to the normal ward nursing staff, there is one permanent orthopaedic physiotherapist, a rotating physiotherapist, and one occupational therapist. Key members of the department (including the elective ward charge nurse, the senior permanent physiotherapist, and the clinical leader) attended a 1-day workshop on the principles and implementation of enhanced recovery (Wainwright & Middleton, 2010). Having been enthused by the presentation, the team members resolved to introduce the techniques to our institution. Over the next 6 months, all aspects of the patient journey were reviewed. Small-scale audits were conducted on cancellations at the preadmission clinic and on day of surgery, effect of preoperative anemia on transfusion requirements and ALOS, use of drains, use of femoral nerve blocks, and local anesthetic infiltration techniques. New protocols were developed by the nursing, physiotherapy, and medical staff. An experienced former orthopaedic charge nurse was appointed to a part-time ERAS facilitator role, and the head orthopaedic surgeon was the *clinical champion* for the project.

An audit of cancellations at the preadmission clinic showed the commonest reasons for cancellation of surgery were poorly controlled medical conditions, need for dental care, and skin problems such as ulcers. This led to the development of a preoperative health questionnaire concentrating specifically on recent dental care, skin lesions, and chronic health conditions. This was mailed to patients and general practitioners (GPs) prior to the preadmission appointment. Problems were identified and addressed, and surgery was delayed if necessary. An audit of preoperative anemia showed that patients who were anemic (males <130 g/L, females <120 g/L) stayed a mean 1.6 days longer than those patients who were not anemic (6.8 vs. 5.2 days) and 56% of anemic patients required transfusion compared with 12.5% of nonanemic patients. This led to the development, in conjunction with the Hematology Department, of an algorithm for the early identification and management of preoperative anemia. Facilities and arrangements for intravenous iron infusion and oral iron supplementation were developed for patients with preoperative iron-deficient anemia.

Community service physiotherapists and occupational therapists had seen patients from the historical cohort for education and aids such as raised toilet seats and crutches. Although education was given, this was not always consistent or up to date. A new preoperative education class was developed for all patients who lived within 1-hour travel time from our hospital and run by members of the elective ward staff. Aids were issued, and patients were instructed on preoperative physiotherapy exercises. Details of their postoperative care and expectations were given by the staff who would be looking after them, which ensured continuity. The patient information guide was rewritten to reflect a shifting of responsibility onto the patient and the family in areas such as smoking cessation and discharge planning.

Standardized anesthetic and analgesia guidelines were developed with a consultant anesthetist (see Table 1). The goal was for mobilization of the patient on the day of surgery if possible and better management of postoperative pain. Key initiatives included the routine administration of tranexamic acid (if no contraindications) and increased use of parenteral and oral nonsteroidal anti-inflammatory drugs. A randomized study we conducted showed no advantages to postoperative continuous femoral nerve infusions over a single-shot femoral nerve block, so their use was discouraged (Wyatt, Wright, Locker, Stout, & Theis, 2015). In turn, femoral nerve block has been superseded by local infiltration with ropivacaine, adrenaline, and tranexamic acid in patients undergoing knee replacements.

Discharge criteria were developed so that in a medically fit patient the final decision on discharge is made by the nursing and physiotherapy staff. Patients should be independent for transfers in and out of bed, have managed stairs and showering, and have satisfactory knee flexion (for knee replacement patients) prior to discharge. The ERAS team consulted and discussed the new protocols with all orthopaedic surgeons, junior doctors, anesthetists, nursing staff, inpatient and outpatient physiotherapists, and local GPs.

Following discussion and small-scale trials, the new protocols were implemented in January 2013. Key aspects are summarized in Table 2.

This study compares a consecutive series of all patients undergoing primary elective total hip (THR) or knee replacement (TKR) from January 1, 2013, to June 30, 2014, with a historical control cohort from the preceding 18-month period, July 1, 2011, to December 31, 2012. Revision surgery and hip replacement for acute fractures were excluded. Data including age, gender, body mass index (BMI), ALOS, time of discharge, transfusion requirements, and acute readmissions were collected prospectively.

Baseline data collected included the American Society of Anesthesiologists (ASA) grade. This has five grades, where ASA I is a healthy patient, ASA II is a patient with mild systemic disease, ASA III is a patient with severe systemic disease, and ASA IV is a patient with severe systemic disease that is a constant threat to life. ASA V is a moribund patient who is not expected to survive without the operation and is not relevant to elective joint replacement. (ASA, 2014) Preoperative Oxford hip or knee scores (OHS, OKS), which are used in our prioritization process, were also collected for the ERAS group. The Oxford score is a 12-question patient-reported outcome measure. There are five questions on pain and seven on function, each of which has five options and is scored 0–4, where 0 is worst and 4 is best. This gives a score of 0–48, where 48 is best. The score is validated and widely used to report the improvement

Table 1. Anesthesia Guideline for THJR/TKJR

This is only a guideline. It is recognized that the attending anesthetist may find it necessary to alter this in certain circumstances depending on the patient's individual needs. Please contact APS early if the patient is opioid tolerant.
Spinal anesthesia +**intrathecal morphine** 100–150 μg
Sedation or **light general anesthesia**
Maintain spontaneous ventilation where possible
Maintain **normothermia**
Cefazolin 2 g prior to skin incision and tourniquet inflation
Consider **tranexamic acid** 15 mg–20 mg/kg iv slowly prior to incision if excessive blood loss is expected or the patient is anemic (Hb <130 g/L, males, 120 g/L females)
Avoid excessive **fluids**, i.e., 1–2 L in routine cases; aim for approximately 3 L in the first 24 hours
Paracetamol 2 g as a premed or 1 g iv intraoperatively
Parecoxib 40 mg iv if not contraindicated, i.e., allergy, severe asthma, PUD, abnormal creatinine, >75-year-old. Consider continuing for 3 days postop
TKJR only
Femoral nerve block (single shot): Bupivacaine 100 mg, or ropivacaine 150 mg + dexamethasone 8 mg
OR **Peri/intra-articular local anesthetic:** Ropivacaine 200–300 mg + adrenaline 1 mg + 1 g tranexamic acid (in place of IV dose made up to 100 mL with normal saline)
Postoperative analgesia to consider
Paracetamol 1 g qid regular
Ibuprofen 200–400 mg 8 hourly 3 days and then stop + omeprazole 40 mg od while on Ibuprofen
PCA for 1–2 days for patients who underwent knee replacement started in recovery; prn for patients who underwent hip replacement
Oxycontin Knees only 10 mg bd. Start postop Day 1 for 3 days and then stop
Oxynorm 5–10 mg po q3h prn (not while on PCA) review on D/C
Clonidine patch tts1 start once mobilizing (Day 1)
Tramadol 50–100 mg qid/prn (avoid if SSRIs, previous intolerance, seizures)

Note. bd = twice daily; D/C = discharge; od = once daily; Hb = hemoglobin; iv = intravenous; PCA = patient-controlled analgesia; po = per os or orally; prn = as needed; PUD = peptic ulcer disease; qid = four times a day; q3h = every 3 hours; SSRI = serotonin-specific reuptake inhibitor; THJR = total hip joint replacement; TKJR = total knee joint replacement.

and outcome following hip or knee replacement surgery (Murray et al., 2007).

Complications and readmission data were collected from our institution's patient management system, the department's surgical audit system, and the surgical site infection (SSI) surveillance program for hip and knee replacements. Data were cross-referenced with the New Zealand (NZ) Joint Registry for revisions, deaths, and 6-month postoperative Oxford scores. The NZ Joint Registry (2014) collects details of all patients undergoing hip or knee replacement in the country and has 98% compliance.

Table 2. Key Components of the ERAS Program

Early identification and treatment of preoperative anemia
Preoperative health questionnaires to patients and GPs
Weekly preoperative education class run by the ward nursing and allied health staff
Rewritten patient information guide
Streamlined preadmission process
Day of surgery admission for all patients
Standardized anesthetic and analgesia guidelines
Intraoperative local anesthetic infiltration
Perioperative blood management algorithm
Day of surgery mobilization
Development of nurse- and physiotherapy-led discharge criteria

Note. ERAS = enhanced recovery after surgery; GP = general practitioner.

The study was approved by the University of Otago Human Ethics committee (Health). Statistical analysis was performed using Stata v13 (College station, TX). Two-tailed *t* tests were used for continuous variables and chi-square tests for categorical data.

Results

There were 507 patients who underwent primary elective hip and knee replacements in the historical control group and 528 in the ERAS group. The groups were well matched with respect to age, gender, and ASA grade (see Table 3). The mean age for patients who underwent hip replacement was 68 years and for patients who underwent knee replacement was 70 years. In both groups, 30% of patients were ASA Grades III and IV, indicating the presence of severe systemic comorbidities. In the ERAS group, the median BMI was 31.7 kg/m^2 and the mean preoperative OHS was 11.1 (*SD* = 4.9) and OKS was 11.1 (*SD* = 4.0). These data were not available for the historical cohort but are likely to be very similar.

The day of surgery admission rate increased from 96% in the control group to 99% in the ERAS group. The average ALOS for elective THR fell significantly by 1.3 days and by 0.9 days for TKR, with the main drop occurring almost immediately following the introduction of the new protocols, especially for THR (see Figure 1). There was a shift to discharges later in the day during the course of the study. If patients were able to be discharged in the afternoon or evening after their physiotherapy, they did not have to wait for a medical ward round the following day. Patients who were mobilized on the day of surgery had an ALOS 1 day shorter than those who did not. Twenty-one patients (4%) were discharged to a rehabilitation ward or rural hospital bed. The mean age of these patients was 76 years, and 17 (81%) were patients who underwent hip replacement.

Following the introduction of the perioperative anemia management pathway, the transfusion rate dropped from 26% to 17% for patients who underwent hip replacement (p = .18) and was unchanged for patients who underwent knee replacement at 9%. There was a 40% reduction in the number of units of blood transfused per patient. The median length of stay (LOS) for patients with preoperative anemia was 5 days compared with 4 days for nonanemic patients.

Two in-hospital deaths occurred in ASA Grade III patients. A 78-year-old died of aspiration pneumonia after prolonged hypotension following a hip replacement. An 80-year-old developed cardiogenic shock following knee

Table 3. Comparison of Demographic Details and Outcomes of the Two Groups Pre- and Postimplementation of ERAS Changes

	2011–2012 Pre-ERAS	2013–2014 Post-ERAS	*p*
Hip	314	318	
Male:Female	146 (46%):168 (54%)	146 (46%):172 (54%)	.88
Age (years), mean (*SD*)	66.8 (11.8)	68.3 (11.8)	.10
ASA Grades III and IV	93 (30%)	104 (33%)	.40
Mean LOS (*SD*)	5.6 (2.1)	4.3 (1.9)	**<.00001**
Median (IQR)	5 (4–6)	4 (3–5)	
Mean preop Oxford score (*SD*)	Not available	11.1 (4.9)	
Mean 6-month Oxford score (*SD*)	36.6 (8.7)	38.8 (7.8)	.152
Revisions	3 (0.96%)	4 (1.26%)	.7
Knee	193	210	
Male:Female	83 (43%):110 (57%)	107 (51%):103 (49%)	.11
Age (years), mean (*SD*)	69.8 (9.0)	70.4 (8.9)	.54
ASA Grades III and IV	58 (30%)	67 (32%)	.52
Mean LOS (*SD*)	5.7 (1.8)	4.8 (1.8)	**<.00001**
Median (IQR)	5 (5–6)	4 (4–5)	
Mean preop Oxford score	Not available	11.1 (4.0)	
Mean 6-month Oxford score (*SD*)	36.3 (7.4)	39.8 (6.6)	**.03**
Revisions	2 (1.04%)	0 (0%)	.139
Hips and knee combined	507	528	
Deaths 30 days	1 (0.2%)	3 (0.57%)	.336
Deaths 90 days	2 (0.4%)	4 (0.76%)	.442
Readmissions <30 days	16 (3.2%)	29 (5.5%)	.065

Note. ASA = American Society of Anesthesiologists; ERAS = enhanced recovery after surgery; IQR = interquartile range; LOS = length of stay; OHS = Oxford hip score (0–48); OKS = Oxford knee score (0–48). The chi-square test used for categorical data; the *t* test for continuous variables. Boldface indicates statistical significance.

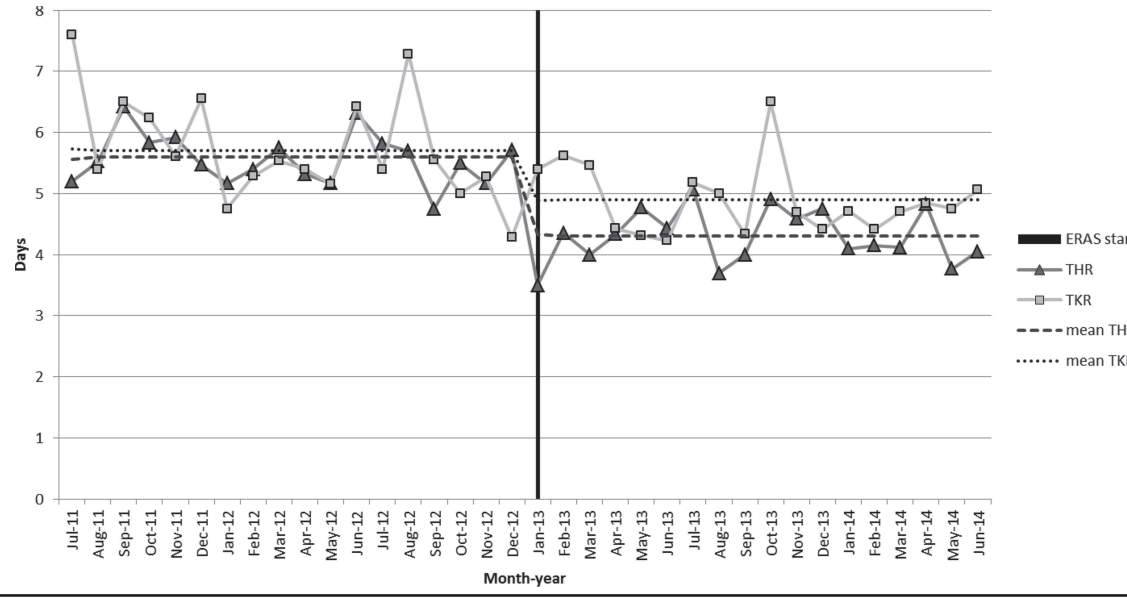

FIGURE 1. Graph showing length of stay by month for primary elective THR and TKR before and after implementation of the ERAS program. ERAS = enhanced recovery after surgery; THR = total hip replacement; TKR = total knee replacement.

replacement and died despite acute coronary artery bypass grafting. Two patients (aged 86 and 79 years, ASA Grade IV with multiple comorbidities) died following discharge to residential care at 30 and 50 days, respectively. The 30-day and 90-day death rates were not significantly different from those of the historical cohort (see Table 3).

There were five confirmed SSIs out of 528 hip and knee replacements (0.9%). Four patients (0.75%) required a return to the operating theater: two patients who underwent knee replacement for superficial infection and wound breakdown, and one patient for a hematoma following hip replacement. A 78-year-old man required revision of an uncemented hip at 4 days due to an early dislocation because of loose undersized components. Three other patients who underwent hip replacement had revision at 28, 133, and 455 days for dislocation, giving a hip revision rate of 1.3%. No patients who underwent knee replacement had revision. The revision rates were not significantly different from those seen in the historical cohort.

There was an increase in the 30-day readmission rate from 3.2% (16 of 507) to 5.5% (29 of 528) (ns, $p = .065$). In the ERAS group, the commonest reasons for readmission were for wound problems and suspected infection ($n = 9$), pain issues ($n = 7$), and concerns regarding leg swelling and deep vein thrombosis ($n = 4$). Only four patients from the historical group were readmitted for these reasons.

Regular qualitative patient surveys were performed, with high satisfaction reported. The 6-month Oxford scores were higher in the ERAS group by 3.5 points for patients who underwent knee replacement ($p = .03$) and 2.2 points for patients who underwent hip replacement (ns, $p = .152$) (see Table 2).

Compared with the historical group, there was a saving of 601 bed nights over the 18-month study period or 400 bed nights per year. This represents a theoretical bed night reduction of 20%. However, in practice, this opened up the beds for additional patients with an increase in elective admissions of 10.7% and 6% for acute admissions, resulting in no significant change in the total number of orthopaedic bed nights. The increase in readmissions led to an extra 97 nights (163 nights vs. 68 nights in the control cohort).

Discussion

There has been a trend toward shorter LOS following hip and knee replacements over the last two decades. Day of surgery admission has become the norm in our unit, and only in exceptional circumstances are patients not admitted on the day of surgery regardless of their place of residence, age, or family supports.

Enhanced recovery initiatives have been shown across the world to improve patient outcomes and can reduce the LOS to 2–4 days for patients undergoing hip and knee replacements even in unselected cohort studies (Kehlet, 2013). In practice, many hospitals have longer stays than this and may discharge patients to rehabilitation facilities rather than home. However, in the United Kingdom, it appears that hospital stays of around 5 days are achievable with the widespread implementation of ERPs in public hospitals and not just in dedicated specialist units (Kehlet, 2013).

This study reports on a consecutive unselected group of the first 528 primary hip and knee replacements performed in our public hospital following the implementation of the ERAS program. No patients were excluded. The mean age of 68 years for patients undergoing hip replacement and 70 years for patients undergoing knee replacement was typical for public hospital patients (Dakin, Gray, Fitzpatrick, MacLennan, & Murray, 2012; Jenkins et al., 2013; Malviya et al., 2011; McDonald et al., 2012; Wainwright & Middleton, 2010). The BMI (31.7 kg/m^2) was higher than NZ averages for hip (28.7 kg/m^2) and knee (31.1 kg/m^2) (NZ Joint Registry, 2015). The proportion of patients with ASA Grades III and IV (32.7%) was higher than that reported by Wainwright

and Middleton (2010; 8.5%) and the NZ Joint Registry (2015; 23%–25%). In our district, we have a population that is older than the national average and has had problems with access to hip and knee replacements (Gwynne Jones, 2013; Gwynne Jones & Iosua, 2016). Many patients undergoing surgery had been waiting for 12–18 months due to financial constraints. Most patients had severe disease and were significantly deconditioned. This is reflected in the average preoperative Oxford score of 11 points for both hip and knee replacements compared with average preoperative Oxford scores of 18–20 points reported by others (Dakin et al., 2012; Jenkins et al., 2013; McDonald et al., 2012). Despite this, we were able to show significant changes in our LOS, with only a small increase in readmission rates. Our median LOS dropped from 5 to 4 days for patients who underwent knee or hip replacements, and the reduction in mean LOS is comparable with other published results from the United Kingdom (Kotze, Carter, & Scally, 2012; Malviya et al., 2011; McDonald et al., 2012; Robinson, Wagstaff, Sanghera, & Kerry, 2014; Wainwright & Middleton, 2010). Units in the United States have reported decreases in LOS of 3.4–3.5 days with similar strategies including preoperative education classes and pain management (Kearney et al., 2011; Parisien, Valentine, Hoffman, & Penzero, 2012). However, LOS figures can be misleading if some patients are discharged to step-down facilities. Large studies from the United States have shown that, despite a mean LOS of 3.9–4.2 days, 34%–48% of patients are discharged to rehabilitation or skilled nursing facilities (Schairer, Vail, & Bozic, 2014; Zmistowski et al., 2013). Our figure of 96% discharged home is very similar to that of the Bournemouth group in England (Wainwright & Middleton, 2010).

It has been shown previously that transfusion is associated with longer hospital stays and readmission rates (Ibrahim et al., 2013; Kotze et al., 2012) and preoperative hemoglobin level predicts ALOS independent of transfusion (Kotze et al., 2012). In our initial audit, we noted that preoperative anemia was associated with an increase in median LOS of 1.5 days. The increase in median LOS is now 1 day. Our transfusion rate remains higher than that of other studies (Irwin et al., 2013; Kotze et al., 2012; Malviya et al., 2011; McDonald et al., 2012). If this can be further reduced, there are potential benefits both in terms of LOS and in the costs of blood transfusion.

The complication rate has not increased significantly. Our SSI rate of 0.9% is similar to the NZ average of 1.2% (Morris, 2014) and at this stage no deep infections have been identified. The return-to-theater rate of 0.75% compares favorably with reported rates of 1.3%–1.8% (Irwin et al., 2013; Malviya et al., 2011). The 30-day readmission rate increased from 3.2% to 5.5%, but this is still similar to the 28-day readmission rates of 3.1%–8.5% reported by others (Irwin et al., 2013; Malviya et al., 2011; Schairer et al., 2014; Wainwright & Middleton, 2010; Zmistowski et al., 2013). It is concerning that the number of readmissions directly related to the orthopaedic procedure such as wound problems, pain, and swelling has increased. It is not clear whether this is related to the age and comorbidities of the patients or early discharge.

The 30-day and 90-day death rates of 0.57% and 0.76% are a little higher than those reported in other contemporary series (Cusick & Beverland, 2009; Hunt et al., 2013; Malviya et al., 2011; Sharrock, Della Valle, Go, Lyman, & Salvati, 2008). This may reflect the high proportion of patients who were ASA Grades III and IV. Malviya et al. (2011) reported a reduction in mortality rates, with ERPs from 0.5% to 0.1% in an unselected group of patients of a similar age, but did not report ASA grade. Data from the U.K. registry have shown a reduction in 90-day mortality from 0.56% to 0.29% over the 8 years from 2003 to 2011 (Hunt et al., 2013).

Like others, we found patient satisfaction was high (Jones et al., 2014; Kearney et al., 2011; Parisien et al., 2012). The education classes were particularly well received. The 6-month postoperative OKSs of 39.8 in the ERAS group were 3.5 points higher than those of the historical group and higher than the NZ average of 37.4 (NZ Joint Registry, 2015). The minimum clinically important difference in Oxford score has been reported as 5 points but may be as little as 2 points (Beard et al., 2013; Murray et al., 2007). Therefore, patients in the ERAS had at least equivalent outcomes at 6 months to the historical cohort. The early revision rate (1.3% at minimum 18-month follow-up) for patients who underwent hip replacement is comparable with the NZ Joint Registry rate of 1.1% at 1 year and 1.6% at 2 years (NZ Joint Registry, 2015).

A strength of this study is that it reports on a consecutive group of patients presenting to a general public hospital with significant comorbidities and severe symptoms. There were multiple surgeons and anesthetists of varying grade involved in the surgery, and a variety of implants were used. This suggests that the interventions are generalizable and similar results can be achieved in other institutions.

A limitation of our study is the use of a historical control group, although the patients were well matched. During the development of our protocols, we noted a small drop in ALOS. In the first 6 months of the historical cohort period, the ALOS was 5.8 days for patients who underwent hip replacement and 6.1 days for patients who underwent knee replacement. The ALOS had fallen to 5.4 days for patients who underwent hip replacement and 5.5 days for patients who underwent knee replacement by the date we formally *went live*. The dramatic drop after this date is particularly evident for patients who underwent hip replacement and strongly suggests that the gains were due to the new program. If we took the first 6-month period of the control group as our baseline, then the potential benefits would increase to 500 bed nights per year. This is in part offset by the increased bed nights due to readmissions.

Some of the improvements were small and may not, on their own, have been shown to have a statistically significant effect. However, a key component of programs such as these is the *aggregation of marginal gains* (Durrand, Batterham, & Danjoux, 2014). The end result of all the small changes has resulted in significant reductions in key outcomes such as LOS.

For a project such as this to succeed, strong clinical input is needed. It proved critical to engage and enthuse the senior nursing and allied health staff on the ward.

Most of the changes instituted were nurse or physiotherapist led. The change in attitudes of surgeons and the junior medical staff followed. Many of the changes can be implemented without any increase in budget. A key failing of the project was that there were no mechanisms to return any of the gains to the department for the benefit of orthopaedic patients. Sustainability has been a challenge. Increasing financial pressures, the loss of key staff, medical outliers on the orthopaedic ward, and nursing shortages are constant threats to the continuing success of the program.

Conclusion

Enhanced recovery programs for patients undergoing hip and knee replacements can significantly reduce the LOS without relying on step-down or rehabilitation facilities. They are effective for an unselected public hospital population with severe osteoarthritis and significant comorbidities and have good outcomes, high patient satisfaction, and no increase in complications. Strong nursing, physiotherapy, and clinical leadership and a multidisciplinary approach are required.

Acknowledgments

Terry Wall, Charge Nurse Elective Orthopaedics, and Clare Hargest, physiotherapist, for their work in developing and implementing the new procedures; Dr. Justin Holborrow for developing the anesthetic guidelines; Dr. Jim Faed, consultant hematologist and transfusion medicine specialist, for help in developing the perioperative anemia algorithm; Associate Professor Bob Hancox, for help with statistical analysis; and Messrs Rob Middleton and Tom Wainwright, for their advice and enthusiasm on setting up the program.

References

American Society of Anesthesiologists. (2014). *ASA physical status classification system*. Retrieved April 1, 2016, from https://www.asahq.org/resources/clinical-information/asa-physical-status-classification-system

Beard, D. J., Dawson, J., Harris, K., McKibbin, H., Jenkinson, C., & Price, A. J. (2013). *Minimal important change or difference for the Oxford hip or knee scores*. Retrieved June 10, 2015, from https://www.isakos.com/meetings/2013congress/onsite/AbstractView?EventID=6164

Cusick, L. A., & Beverland, D. E. (2009). The incidence of fatal pulmonary embolism after primary hip and knee replacement in a consecutive series of 4253 patients. *The Journal of Bone and Joint Surgery*, *91(B)*, 645–648.

Dakin, H., Gray, A., Fitzpatrick, R., MacLennan, G., & Murray, D. The KAT Trial Group. (2012). Rationing of total knee replacement: A cost-effectiveness analysis on a large trial data set. *BMJ Open*, *2*, e000332. doi:10.1136/bmjopen-2011-000332

Durrand, J. W., Batterham, A. M., & Danjoux, G. R. (2014), Pre-habilitation (i): Aggregation of marginal gains. *Anaesthesia*, *69*, 403–406. doi:10.1111/anae.12666

Gwynne Jones, D. P., (2013). Quantifying the demand for hip and knee replacement in Otago, New Zealand. *The New Zealand Medical Journal*, *126*, 1377.

Gwynne Jones, D. P., & Iosua, E. (2016, April 1). Rationing of hip and knee replacement: Effect on the severity of patient reported symptoms and the demand for surgery in Otago. *The New Zealand Medical Journal*, *129*, 1432.

Hunt, L. P., Ben-Schloma, Y., Clark, E. M., Dieppe, P., Judge, A., MacGregor, A. J., … National Joint Registry for England, Wales and Northern Ireland (2013). 90-day mortality after 409096 total hip replacements for osteoarthritis, from the National Joint Registry for England and Wales: A retrospective analysis. *The Lancet*, *382*, 1097–1104.

Ibrahim, M. S., Twaij, H., Giebaly, D. E., Nizam, I., & Haddad, F. S. (2013). Enhanced recovery in total hip replacement. A clinical review. *The Bone and Joint Journal*, *95(B)*, 1587–1594.

Irwin, A., Khan, S. K., Jameson, S. S., Tate, R. C., Copeland, C., & Reed, M. R. (2013). Oral versus intravenous tranexamic acid in enhanced-recovery primary total hip and knee replacement. *The Bone and Joint Journal*, *95-B*, 1556–1561.

Jenkins, P. J., Clement, N. D., Hamilton, D. F., Gaston, P., Patton, J. T., & Howie, C. R. (2013). Predicting the cost-effectiveness of total hip and knee replacement. A health economic analysis. *The Bone and Joint Journal*, *95(B)*, 115–121.

Jones, E. L., Wainwright, T. W., Foster, J. D., Smith, J. R. A., Middleton, R. G., & Francis, N. K. (2014). A systematic review of patient reported outcomes and patient experience in enhanced recovery after orthopaedic surgery. *Annals of the Royal College of Surgeons of England*, *96*, 89–94.

Keane, C., Savage, S., McFarlane, K., Seigne, R., Robertson, G., & Eglinton, T. (2012). Enhanced recovery after surgery versus conventional care in colonic and rectal surgery. *Australian and New Zealand Journal of Surgery*, *82*, 697–703.

Kearney, M., Jennrich, M. K., Lyons, S., Robinson, R., & Berger, B. (2011). Effects of preoperative education on patient outcomes after joint replacement surgery. *Othopaedic Nursing*, *30*(6), 391–396.

Kehlet, H. (1997). Multimodal approach to control postoperative pathophysiology and rehabilitation. *British Journal of Anaesthesia*, *78*, 606–617.

Kehlet, H. (2013). Fast-track hip and knee arthroplasty. *The Lancet*, *381*, 1600–1602.

Kehlet, H., & Thienpont, E. (2013). Fast-track knee arthroplasty—Status and future challenges. *The Knee*, *20*(S1), S29–S33.

Kotze, A., Carter, L. A., & Scally, A. J. (2012). Effect of a patient blood management programme on preoperative anaemia, transfusion rate and outcome after primary hip or knee arthroplasty: A quality improvement cycle. *British Journal of Anaesthesia*, *108*(6), 943–952.

McDonald, D. A., Siegmeth, R., Deakin, A. H., Kinninmonth, A. W. G., & Scott, N. B. (2012). An enhanced recovery programme for primary total knee arthroplasty in the United Kingdom—Follow up at one year. *The Knee*, *19*, 525–529.

Malviya, A., Martin, K., Harper, I., Muller, S. D., Emmerson, K. P., Partington, P. F., & Reed, M. R. (2011). Enhanced recovery program for hip and knee replacement reduces death rate. A study of 4,500 consecutive primary hip and knee replacements. *Acta Orthopaedica*, *82*(5), 577–581.

Morris, A. (2014). *National orthopaedic SSI report April to June 2014*. Retrieved from http://www.hqsc.govt.nz/our-programmes/health-quality-evaluation/projects/quality-and-safety-markers/qsms-july-september-2014/#[SSI]

Murray, D. W., Fitzpatrick, R., Rogers, K., Pandit, H., Beard, D. J., Carr, A. J., & Dawson, J. (2007). The use

of the Oxford hip and knee scores. *The Journal Bone and Joint Surgery*, *89(B)*, 1010–1014.
New Zealand Joint Registry. (2015). *Sixteen year report*. Retrieved from http://www.nzoa.org.nz/system/files/NZJR2014Report.pdf
Parisien, K. R., Valentine, D., Hoffman, V., & Penzero, J. (2012). Enhancing the patient's experience through the total joint replacement continuum of care. *Orthopaedic Nursing*, *3*(6), 322–325.
Robinson, K. P., Wagstaff, K. J., Sanghera, S., & Kerry, R. M. (2014). Postoperative pain following primary lower limb arthroplasty and enhanced recovery pathway. *Annals of the Royal College of Surgeons of England*, *96*, 302–306.
Schairer, W. W., Vail, T. P., & Bozic, K. J. (2014). What are the rates and causes of hospital readmission after total knee arthroplasty? *Clinical Orthopaedics and Related Research*, *472*, 181–187.
Sharrock, N. E., Della Valle, A. G., Go, G., Lyman, S., & Salvati, E. A. (2008). Potent anticoagulants are associated with a higher all-cause mortality rate after hip and knee arthroplasty. *Clinical Orthopaedics and Related Research*, *466*, 714–721.
Wainwright, T., & Middleton, R. (2010). An orthopaedic enhanced recovery pathway. *Current Anaesthesia & Critical Care*. doi:http://dx.doi.org/10.1016/j.cacc.2010.01.003
Wyatt, M., Wright, T., Locker, J., Stout, K., & Theis, J. C. (2015). Femoral nerve infusion after primary total knee replacement: A prospective, double-blind randomized and placebo controlled trial. *Bone Joint Research*, *4*, 11–16.
Zmistowski, B., Restrepo, C., Hess, J., Adibi, D., Cangoz, S., & Parvizi, J. (2013). Unplanned readmission after total joint arthroplasty: Rates, reasons and risk factors. *The Journal of Bone and Joint Surgery*, *95(A)*, 1869–1876.

For more than 130 additional continuing nursing education activities related to orthopaedic nursing, go to nursingcenter.com/ce.

Calendar

Regional Offerings

August 17, 2017—**Orthopaedic Nursing Review Course.** Hospital for Joint Diseases, Loeb Auditorium, 301 E. 17th St., New York, NY 10003.

October 24 - October 27, 2017— **ANZONA 2017.** Pan Pacific Hotel, Adelaide Terrace, 207, Perth, WA 6000, Australia.

November 9, 2017—**Movement is Life Caucus.** Washington Marriott at Metro Center, 775 12th St. NW, Washington, D.C., 20005; http://www.movementislifecaucus.com/.

National Offerings

June 22, 2017—**The AOA/NAON Own the Bone Symposium** will be held in Charlotte, NC.

NAON Member Benefit Webinar Series

To register for Webinars, go to: http://www.orthonurse.org/p/cm/ld/fid=33

Advance Practice Webinars in 2016 (Registration Fee Required)

Tuesday, August 15, 2017—*Prevention of Postoperative Nausea and Vomiting after Joint Replacement*