

# A rapid recovery protocol for hip and knee replacement surgery: a report of the outcomes in a referral center

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**Abstract. – OBJECTIVE:** The number of joint replacements is expected to dramatically increase, and the optimization of the available resources is fundamental to maintain high clinical standards while providing an efficient treatment to an increasing number of patients. The present study describes the outcomes of the application of a rapid recovery (RR) protocol in a referral center for hip and knee replacement surgery.

**PATIENTS AND METHODS:** The medical records of every patient undergoing primary hip or knee replacement in 2019 were identified and all the relevant data were retrospectively extracted and compared to those of year 2016 (the last year before the onset of the rapid recovery protocol). The following outcomes were considered: 1) length of stay (LOS); 2) total number of TKR and THR; 3) pre- and post-operative subjective questionnaires; 4) NRS for pain at day 1 following surgery; 5) mean hemoglobin value at discharge; 6) number of blood transfusion performed; 7) complications following surgery.

**RESULTS:** The mean LOS was significantly lower for patients managed through the rapid recovery protocol:  $5.1 \pm 1.4$  days vs.  $10.4 \pm 2.3$  days ( $p < 0.0001$ ). The earlier discharge of patients promoted an overall increase in the total number of joint replacement procedures performed (2,806 in year 2019 vs. 2,236 in year 2016;  $p < 0.0001$ ). Higher hemoglobin values at discharge were found in the RR group ( $10.6 \pm 1.4$  g/dl vs.  $9.6 \pm 1.2$  g/dl,  $p = 0.049$ ). No difference was observed in terms of clinical scores and overall complication rate.

**CONCLUSIONS:** The application of a multimodal RR protocol for THR and TKR patients was able to reduce the length of stay and optimize the use of blood products, without increasing the risk of complications or jeopardizing the functional recovery.

*Key Words:*

Fast track, Rapid recovery, Knee replacement, Hip replacement, Blood management, Early discharge.

## Introduction

The number of total knee replacement (TKR) and total hip replacement surgeries (THR) are expected to dramatically increase over the course of the next three decades both in and outside Europe<sup>1</sup>. For example, In France<sup>2</sup>, the number of hip surgeries is forecasted to rise between 41.9% and 114.3% by 2050. In Australia<sup>3</sup>, hip and knee surgeries are forecasted to increase respectively by 208% and 276%. Similarly, In the United States<sup>4</sup>, hip surgeries are forecast to increase by 79% up to 129%, whilst knee surgeries are predicted to rise by 182% up to 401% in the next decades. Looking from the Italian perspective, between 2001 and 2015, elective hip and knee replacement surgeries increased by 141% and 249%, respectively<sup>5</sup>.

This massive increase is due to several factors, including the aging of the population, and the mounting participation in high impact recreational sports activity<sup>6</sup>. Giving the huge numbers of joint replacement surgery, a concern about the economic and organizational sustainability has been rising over the last years. Optimizing the use of resources is mandatory to maintain an efficient healthcare system that can quickly provide a joint replacement to every patient who need, minimizing the economic impact and the social burden of a surgery which is not lifesaving. In the present scenario, the introduction of Rapid Recovery (RR) programs for patients undergoing

joint replacement surgery could represent one of the winning strategies to maintain the sustainability of the system, regardless of the number of procedures performed<sup>7</sup>.

Among all the parameters considered to analyze the economic and social impact of joint replacement surgery, the length of stay (LOS) represents one of the most relevant. According to Molloy et al<sup>8</sup>, from a retrospective cost analysis carried on 6.4 million TKR and 2.8 million THR in the US, performed in the period between 2002 and 2013, the cost per procedure increased by 52.4% (TKR) and 49.8% (THR) respectively, with a reduction in LOS from 4.06 to 2.97 days (TKR) and from 4.06 to 2.75 days (THR). Without the recorded LOS reduction, the increase of the costs per procedure would have been 70.8% for TKR and 67.4% for THR. The role of LOS reduction was further highlighted by Büttner et al<sup>7</sup> in a recent systematic review in which they noticed how the introduction of a fast-track path can significantly reduce the cost of treatment without negatively impacting on the clinical outcomes, but even improving them. Khan et al<sup>9</sup> also highlighted the economic impact of a multidisciplinary enhanced recovery (ER) strategy by comparing two groups of about 2,600 patients and documenting, in the ER group, a reduction of about 11,600 days of hospitalization, thus saving approximately \$3.5 million, also due to a significant reduction in transfused blood products, which provided additional savings in the range of \$145-\$166 for each non-transfused unit. One of the critical issues regarding fast-track paths concerns the absence of a shared definition of a fast-track protocol, which could help to standardize the RR approach and better analyze the clinical and economic benefits of this protocol on a large scale<sup>10</sup>. The hypothesis of the present study is that the application of a rapid recovery protocol for hip and knee replacement surgery in an Italian referral center with high flow of patients could provide a better optimization of resources while maintaining the same clinical outcomes. The purpose of the present study was to compare the clinical and economical outcomes following the application of a RR protocol to those of a “traditional” management of hip and knee replaced patients.

## Patients and Methods

### Study Design

The medical records of every patient undergoing primary hip or knee replacement in our

hospital in 2016 and 2019 were identified, and all the relevant data were retrospectively extracted, anonymized and collected in Microsoft Excel sheets for the purpose of the present analysis. Each medical record was independently analyzed by two authors, who separately collected the data and then double-checked them to resolve any incongruency.

Patients who underwent joint replacement for an acute articular fracture were excluded from analysis. Furthermore, simultaneous bilateral hip or knee arthroplasty, and revision arthroplasty (hip or knee) were not included in the study. We also excluded patients with severe comorbidities, who were deemed at too high risk for participating in a rapid-recovery protocol: all these exclusions were agreed upon discussion among the anesthesiologists, internists and orthopedic surgeons and the same criteria were adopted when analyzing the medical records of 2016 (when the rapid recovery protocol was not applied), to minimize any selection and reporting bias.

All the patients signed an informed consent for the use of their anonymized data for scientific purposes, and the Internal Review Board of IRCCS Humanitas Research Center approved the present retrospective study.

### Rapid Recovery Protocol

The Rapid-Recovery protocol has been gradually introduced in our hospital since 2017, and approximately 2 years were required to fully integrate it within the standard of care of our Institute. Therefore, 2019 data have been considered for the present study and compared to those of 2016, which was the last year during which a standard, non-rapid recovery protocol was applied.

The protocol was developed by a working group composed of anesthesiologists, orthopedic surgeons, internists, rehabilitation specialists, physiotherapists and nurses, who followed international guidelines and previously published experiences to draft the protocol.

It consisted of 6 main areas:

- Pre-admission evaluation;
- Hospital admission;
- Surgical strategies;
- Anesthesia and peri-operative pain management;
- Blood management;
- Early rehabilitation strategies.

A detailed description of the measures adopted in each of the 6 domains has been provided in **Supplementary Table I**.

**Analyzed Outcomes**

The following main outcomes were collected by comparing year 2019 (rapid recovery protocol at full regimen) to year 2016 (no rapid recovery protocol applied) (Table I):

- Length of stay in the hospital (primary outcome of the study, expressed in number of days);
- Total number of primary TKA and THA;
- Pre- and post-operative (1 year follow-up) subjective questionnaires (Oxford Knee Score for TKR and Hip Harris Score for THR);
- NRS for pain at day 1 following surgery;
- Mean hemoglobin value at discharge and after 30 days;
- Number of blood transfusion performed;
- Complications following surgery (i.e., deep venous thrombosis, pulmonary embolism, re-admissions within one week for any cause, periprosthetic infections, mortality).

**Statistical Analysis**

Statistical analysis was performed using Prism v5.0 (GraphPad Software, La Jolla, CA, USA). Descriptive statistics were calculated, and nu-

merical variables are here reported as mean ± standard deviation, while categorical variables are reported as counts and percentages (if not otherwise specified). Paired *t*-test or one-way ANOVA (or their non-parametric counterparts, Wilcoxon or Friedman tests) were used with appropriate post hoc tests to compare two or more groups differing for a single variable.

**Results**

A comparison of the demographic data between 2019 and 2016 revealed no significant difference in terms of sex, median age, median BMI, and comorbidities of the patients who received primary THR or TKR (Table II). The median LOS was significantly lower for patients managed through the rapid recovery protocol: 5.1 ± 1.4 days vs. 10.4 ± 2.3 days (*p* < 0.0001). The earlier discharge of patients promoted an overall increase in the total number of joint replacement procedures performed (2,806 in year 2019 vs. 2,236 in year 2016; *p* < 0.0001). This result was achieved without increasing the number of beds in our department and a better performance might have been obtained, but a concurrent marked increase in revision THR or TKR procedures (not included in the present analysis,

**Table I.** Summary of the outcomes considered comparing year 2019 to 2016.

Category	Outcomes
Demographics data	<ul style="list-style-type: none"> <li>• Age</li> <li>• Sex</li> <li>• BMI</li> </ul>
Comorbidities	<ul style="list-style-type: none"> <li>• Hypertension</li> <li>• Diabetes</li> <li>• Heart disease</li> <li>• Other disease</li> </ul>
Surgical interventions	<ul style="list-style-type: none"> <li>• Primary THA performed</li> <li>• Primary TKA performed</li> </ul>
Clinical outcomes	<ul style="list-style-type: none"> <li>• THA: pre- and postoperative Harris hip score</li> <li>• TKA: pre- and postoperative Oxford knee score</li> </ul>
Pain control	<ul style="list-style-type: none"> <li>• NRS at day 1 post-operative</li> <li>• Persistence of chronic pain 1 year after procedure</li> </ul>
Blood management	<ul style="list-style-type: none"> <li>• Mean Hb value at discharge and after 30 days</li> <li>• Number of blood transfusion requested</li> <li>• Number of blood transfusion performed</li> <li>• % of blood components sent back to blood bank</li> </ul>
Complications	<ul style="list-style-type: none"> <li>• Pulmonary embolism and deep vein thrombosis</li> <li>• Hospitalization within 1wk from discharge</li> <li>• Reoperations (within 72hrs from surgery)</li> <li>• Periprosthetic infection in the 1st year postoperative</li> <li>• Mortality</li> </ul>
Hospital Organization	<ul style="list-style-type: none"> <li>• Length of stay (LOS)</li> </ul>

**Table II.** Summary of outcomes considered, comparing 2019 to 2016.

Categories	Outcomes	Mean values		Difference (p)
		2016	2019	
Demographics data	Age	66.7 ± 7.6	68.7 ± 6.6	n.s.
	Sex (M/F)	984/1252	1207/1599	n.s.
	BMI	29.5 ± 5.7	29.8 ± 5.4	n.s.
Comorbidities	Hypertension	1549 (66.3%)	1786 (64.4%)	n.s.
	Diabetes	295 (12.6%)	445 (12.1%)	n.s.
	Heart Disease	320 (13.7%)	383 (13.8%)	n.s.
	Other Disease	140 (6%)	192 (6.9%)	n.s.
Number of surgeries performed	TKA performed	744	866	p = 0.034
	THA performed	1492	1940	p < 0.0001
	First implant	2236	2806	p < 0.0001
Clinical Subjective evaluation	THA: pre- and post-operative Harris Hip score	34.9 ± 4.7 at basal and 88.5 ± 8.3 at 1 year	32.3 ± 5.0 at basal and 88.3 ± 7.1 at 1 year	n.s.
	TKA: pre- and post-operative Oxford Knee score	16.7 ± 6.3 at basal and 36.2 ± 9.5 at 1 year	16.1 ± 6.2 at basal and 37.1 ± 9.1 at one year	n.s.
Pain Control	Evaluation of pain at day 1 post-op (percentage of patients with NRS for pain < 3)	89.50%	96.5%	p = 0.038
	Persistence of chronic pain (NRS>3) 1 year after procedure	5.8%	5.3%	n.s.
Blood Management	Mean Hb value at discharge	9.6 ± 1.2 g/dl	10.6 ± 1.4 g/dl	0.049
	Mean Hb value after 30 days from discharge	12.5 ± 1.3 g/dl	13.7 ± 2.0 g/dl	n.s.
	Percentage of patients requiring blood product transfusion	8%	4%	p = 0.026
	Percentage of blood products sent back to blood bank without being used	43%	23%	p = 0.032
Complications	Pulmonary embolism and deep vein thrombosis	4	3	n.s.
	Hospitalization within 1 wk from discharge	3	2	n.s.
	Reoperation (within 72 hours from surgery)	11	5	n.s.
	Periprosthetic infection during the 1st year	7 (0.3%)	5 (0.2%)	n.s.
	Mortality	0.1%	0.1%	n.s.
Hospital Organization	Length of stay (LOS)	10.4 ± 2.3 days	5.1 ± 1.4 days	p < 0.0001

since the rapid recovery protocol has not yet been applied in those cases) prevented a further rise in primary procedures. In terms of clinical outcomes, the rapid recovery protocol did not jeopardize the functional recovery of patients, as testified by similar subjective scores reported up to 1 year evaluation, both in THR and TKR patients operated in 2019 and 2016. Interestingly, a better post-operative pain control was obtained in the rapid-recovery group. In fact, more than 96% of the operated patients presented NRS for pain < 3/10 at day 1, compared to the 89% of patients

treated by a standard protocol. Another great advantage was reported in the blood products management. Indeed, the rapid recovery protocol allowed an earlier identification of patients at risk of receiving blood transfusion following surgery. These patients, during the pre-admission evaluation, were treated by endovenous administration of 1 gr ferric carboxymaltose to correct anemia and/or iron deficiency. The effects of the blood management protocol were: (1) lower percentage of patients requiring blood products transfusion (4% in 2019 vs. 8% in 2016, p < 0.0001); (2) lower

percentage of blood products being sent back to Blood Bank without being used (23% in 2019 vs. 43% in 2016,  $p < 0.0001$ ); (3) higher hemoglobin value at discharge ( $10.6 \pm 1.4$  g/dl in 2019 patients vs.  $9.6 \pm 1.2$  g/dl in 2016 patients,  $p = 0.049$ ). No significant difference was instead observed in hemoglobin levels at 30 days from discharge in the two groups. Even looking at thromboembolic complications, periprosthetic infections, readmission rate and mortality, no difference was seen between 2019 and 2016, thus showing that the rapid recovery protocol and early discharge did not expose patients to an increased risk of adverse events. All the data retrieved have been summarized in Table II.

## Discussion

The main finding of the present study is that the introduction of a multimodal rapid recovery protocol for THR and TKR patients led to a significant reduction of the length of stay in the hospital, contributing to increase the number of yearly joint replacement procedures. Furthermore, the early identification of patients at risk for blood transfusions, and the inherent application of measures to treat anemia and iron deficiency, led to the optimization in the use of blood products, thus reducing the number of transfusions and the costs for handling hemoderivatives.

Based on the findings of the present study, the goals of the rapid-recovery protocol were met, and this reflects the results reported in the literature in a similar clinical setting<sup>11-13</sup>. The rationale behind the introduction of “fast-track” protocols is the necessity to better allocate human, logistic and economic resources in the field of joint prosthetic replacement, which has been in constant growth in the last decades, due to the ageing of population and the large prevalence of osteoarthritis (OA)<sup>14</sup>. The efficacy of rapid recovery protocols lies in the close collaboration among different professional figures to have a patient-centered approach. The pinnacles of such management are the reduction of blood loss<sup>15</sup> and a proper pain control following surgery<sup>16</sup>, so that the patient is able to start an early rehabilitation protocol, consisting in range of motion exercises and walking with weight bearing as tolerated. The possibility of starting physiotherapy as early as a few hours after surgery has been demonstrated to minimize the risk of post-operative kinesiophobia<sup>17</sup>, leading to better functional outcomes

even in the middle term-evaluation. This result can be achieved through a comprehensive evaluation of the patient, including his/her social setting, comorbidities, expectations and functional needs. Therefore, the pre-admission phase was of utmost importance to detect any risk factor that could bias the outcome of surgery with a peculiar attention to hematopoiesis optimization. At this stage, anemic patients are identified, risk factors pinpointed and the need for blood transfusion forecasted. The protocol included evaluation for serum iron, ferritin, and PCR, and one-gram infusion of ferric carboxymaltose was administered in the following cases: (1) anemic patients (Hb  $< 13$  g/dL) whose ferritin was  $< 100$  mcg/L; (2) non-anemic patients (Hb  $> 13$  g/dL) whose ferritin was  $< 100$  mcg/L; (3) patients whose ferritin was  $> 100$ , PCR  $> 3$  and transferrin saturation (TSAT)  $< 20\%$ . Anemic patients were treated alongside patients falling under the categories defined by Muñoz’s Consensus Statement et al<sup>18</sup>, such as iron-deficient patients and patients with low iron stores. These were conditions that worsen patients’ clinical outcomes. Patients who could not be treated intravenously were orally administered with Vit. C 30 mg/70 mg sucrosomial iron for 30 days<sup>19</sup>.

The main aim of this protocol was to have the majority of patients undergoing surgery with Hb  $> 13$  g/dl and having sufficient iron stores to guarantee post-surgery recovery.

In the intra-operative phase, consistently with other reported experiences, the following strategies were adopted in order to reduce bleeding<sup>20,21</sup>:

- Locoregional anesthesia associated with sedation whenever possible;
- Maintenance of normothermia;
- Optimization of blood salvage through dedicated blood recovery system (especially in patients with expected loss  $> 20\%$  of blood volume);
- Administration of 15 mg/Kg of tranexamic acid 20 minutes before surgery and every 8 hours in the first 24 hours after surgery;
- Use of fibrin glue products to reduce local bleeding;
- Use of tissue-sparing surgical techniques.

Anesthesia and perioperative pain management protocols also played an important role within rapid recovery pathways. An effective pain management allowed surgical stress reduction and enabled rapid patient mobilization, as well as reduced the length of stay<sup>22</sup>. These goals

could be achieved by identifying safe and standardized anesthesia and pain management strategies, which could be implemented by following the patient from admission to discharge, as well as through post-surgery follow-up. It is worth highlighting that the best pain management and anesthesiologic approach needs to be identified in the pre-operative phase. In our study we opted for regional anesthesia (RA), namely subarachnoid anesthesia, combined spinal-epidural anesthesia (CSE), or peripheral nerve blocks (PNBs). In 2019, these kinds of anesthesia were performed in 98.5% of the THR and TKR surgeries, whilst general anesthesia was adopted in 1.5% of cases only.

RA represents an ideal tool for fast-track recovery pathways, since it offers a better post-operative pain management and contributes to post-operative nausea and vomit prevention, as well as enabling successful patient's mobilization few hours after surgery<sup>23,24</sup>.

The setting of a dedicated space to perform RA in the pre-operative and post-operative phase, alongside the contribution given by highly specialized staff, led to a further optimization of cost management whilst having a significantly positive impact on operating theatre turnover time. The use of RA instead of general anesthesia reduced the financial impact and provided a higher level of perioperative safety. Furthermore, in case of knee replacement, we successfully applied a protocol which entailed the combination of post-operative, single shot adductor canal blocks, as well as the Zalviso<sup>®</sup> system (patient-controlled analgesia of sublingual sufentanil), alongside etoricoxib and paracetamol<sup>25</sup>. Anyway, elderly, cognitive impaired, patients with severe lung conditions or opioid intolerant were not eligible for such protocol: therefore, they were treated by an ultrasound-guided peri-nervous catheter for at least 72 hours. The peri-nervous catheter was placed in the middle third of the thigh, in order to avoid local anesthetic cephalic spread, which might have caused a femoral nerve's motor fibers block. The ultrasound-guided peri-nervous catheter was associated with tapentadol, etoricoxib, and paracetamol for pain management purposes. The accidental dislocation of the catheter was prevented by applying cyanoacrylate glue at the catheter insertion level, in order to prevent leakage, as well as by dressing the wound with a plaster covered by transparent film dressing.

All the aforementioned measures allowed us to significantly reduce the in-hospital LOS of

prosthetic patients, with almost a 50% reduction compared to the pre-rapid-recovery period (i.e., approx. 10 days of LOS in 2016 vs. 5 days in 2019). Although this result allowed us to markedly increase the number of procedures performed yearly, it might seem unsatisfactory compared to other studies where shorter LOS were documented, or where patients were even discharged within 24 hours from surgery (the so-called "outpatient setting")<sup>26,27</sup>. This apparent difference deserves a careful evaluation, since it shall not be attributed to a "lower efficacy" of the rapid recovery protocol applied in our Institution, but rather to the "general organization" of our Health System. In fact, the outpatient regimen for prosthetic patients is more feasible in private, insurance-based Health Systems, where the costs for providing constant in-house assistance to the discharged patients (i.e., wound medications, nursing, rehabilitation services and so on) are covered by private funds<sup>28</sup>. Conversely, in Italy and other European countries, the large majority (more than 99,5%) of joint replacement surgeries are performed under the management of the National Health System, at no costs for the patient. Although that guarantees a free access to such procedures to the whole population, it has an impact on the possibility to provide a comprehensive in-house assistance following discharge. In fact, the National Health System currently lacks personnel and economic resources to provide full in-house assistance to all kinds of patients: it therefore prioritizes subjects affected by more serious diseases and with higher impairments, leaving prosthetic patients "relatively" uncovered, due to their overall more favorable general conditions. Based on these premises, the same-day discharge for prosthetic patients cannot be applied in an extensive manner in Italy, even if a further decrease in the LOS might be achieved by perfecting the current fast track protocols.

Recent studies<sup>29,30</sup> have also suggested that rapid recovery protocols might be extended to patients' categories that were usually considered as "not ideal" candidates for this approach, such as those over 80 years of age and, in the next years, we should expect that such protocols will be also adapted for prosthetic revision surgery, whose number will be unavoidably increasing<sup>31,32</sup>.

Some limitations of the present study must be acknowledged: first of all, its retrospective design and, consequently, the fact that all medical records were manually screened, therefore

increasing the risk of missing data or selection bias, despite each record was analyzed by two independent authors to guarantee completeness of data and resolve eventual discrepancies.

## Conclusions

The application of a comprehensive rapid recovery protocol for managing THR and TKR patients was able to reduce the length of stay in the hospital and to optimize the use of blood derived products, without increasing the risk of complications or jeopardizing the functional recovery after discharge. This approach might contribute to a better allocation of economic resources, leading to an increase in the total number of primary procedures performed yearly. Future studies should address the possibility of expanding the application of rapid recovery protocols, with proper modifications, to other orthopedic clinical settings.

### Conflict of Interest

The Authors declare that they have no conflict of interests.

### Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

### Authors' Contribution

Francesco Tasso, Tiziana D'Amato, Alessandra De Angelis, Berardo Di Matteo and Marco Scardino designed the study protocol. Vincenzo Simili, Giuseppe Monteleone, Federica Martorelli, Daniele Altomare, Alessandra De Angelis, Tiziana D'Amato, Gianluca Campofreda were responsible for data extraction and collection. Francesco Tasso and Berardo Di Matteo were responsible for data analysis and manuscript drafting. Maurilio Marcacci and Marco Scardino critically revised the manuscript. All the authors have read and approved the final version of the paper.

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