Benefits of Enhanced Recovery After Surgery for fusion in degenerative spine surgery: impact on outcome, length of stay, and patient satisfaction

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OBJECTIVE Enhanced Recovery After Surgery (ERAS) proposes a multimodal, evidence-based approach to perioperative care. Thanks to the improvement in care protocols and the fluidity of the patient pathway, the first goal of ERAS is the improvement of surgical outcomes and patient experience, with a final impact on a reduction in the hospital length of stay (LOS). The implementation of ERAS in spinal surgery is in the early stages. The authors report on their initial experience in applying an ERAS program to several degenerative spinal fusion procedures.

METHODS The authors selected two 2-year periods: the first from before any implementation of ERAS principles (pre-ERAS years 2012–2013) and the second corresponding to a period when the paradigm was applied widely (post-ERAS years 2016–2017). Patient groups in these periods were retrospectively compared according to three degenerative conditions requiring fusion: anterior cervical discectomy and fusion (ACDF), anterior lumbar interbody fusion (ALIF), and posterior lumbar fusion. Data were collected on patient demographics, operative and perioperative data, LOSs, 90-day readmissions, and morbidity. ERAS-trained nurses were involved to support patients at each pre-, intra-, and postoperative step with the help of a mobile application (app). A satisfaction survey was included in the app.

RESULTS The pre-ERAS group included 1563 patients (159 ALIF, 749 ACDF, and 655 posterior fusion), and the post-ERAS group included 1920 patients (202 ALIF, 612 ACDF, and 1106 posterior fusion). The mean LOS was significantly shorter in the post-ERAS group than in the pre-ERAS group for all three conditions. It was reduced from 6.06 ± 1.1 to 3.33 ± 0.8 days for the ALIF group ($p < 0.001$), from 3.08 ± 0.9 to 1.3 ± 0.7 days for the ACDF group ($p < 0.001$), and from 6.7 ± 4.8 to 4.8 ± 2.3 days for posterior fusion cases ($p < 0.001$). There was no significant difference in overall complications between the two periods for the ALIF (11.9% pre-ERAS vs 11.4% post-ERAS, $p = 0.86$) and ACDF (6.0% vs 8.2%, $p = 0.12$) cases, but they decreased significantly for lumbar fusions (14.8% vs 10.9%, $p = 0.02$). Regarding satisfaction with overall care among 808 available responses, 699 patients (86.5%) were satisfied or very satisfied, and regarding appreciation of the mobile e-health app in the perceived optimization of care management, 665 patients (82.3%) were satisfied or very satisfied.

CONCLUSIONS The introduction of the ERAS approach at the authors' institution for spinal fusion for three studied conditions resulted in a significant decrease in LOS without causing increased postoperative complications. Patient satisfaction with overall management, upstream organization of hospitalization, and the use of e-health was high. According to the study results, which are consistent with those in other studies, the whole concept of ERAS (primarily reducing complications and pain, and then reducing LOS) seems applicable to spinal surgery.

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KEYWORDS Enhanced Recovery After Surgery; fast-track surgery; spine surgery; interbody fusion; mobile app; e-health

INTRODUCED by Henrik Kehlet in 1997,¹⁶ Enhanced Recovery After Surgery (ERAS) proposes a multimodal, evidence-based approach to perioperative care. Thanks to the overall improvement in care protocols and the fluidity of the patient pathway, the first goal of ERAS is the

improvement of surgical outcomes and patient experience, with an ultimate impact on a reduction in the length of stay (LOS).¹⁵ ERAS procedures involve the optimization of each pre-, intra-, and postoperative stage, placing the patient in a central and proactive position in his or her own

ABBREVIATIONS ACDF = anterior cervical discectomy and fusion; ALIF = anterior lumbar interbody fusion; app = application; ASA = American Society of Anesthesiologists; ERAS = Enhanced Recovery After Surgery; LOS = length of stay; VAS = visual analog scale.

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management.²⁰ ERAS programs are successfully developing in most areas of surgery and offer results that justify the buzz surrounding this concept.²¹ Spinal surgery was finally considered late in the process in this new multimodal organization. After the first (German) study by Fleege et al.¹⁰ demonstrating the value of preoperative patient education in spinal surgery, Wang et al. published the first consecutive series of lumbar fusion cases, detailing key points in their practice, especially the anesthesiological and technical aspects of ERAS.³⁶ Wainwright et al.³⁴ proposed additional methods for the implementation of ERAS protocols in major spinal surgery. However, the bibliography of peer-reviewed studies combining ERAS and spinal surgery, although promising, is still in the early stages.³⁵ Thanks to a synergistic vision of the health group and caregivers at our institution,³³ multidisciplinary work on the implementation of ERAS has been done at our institution since the end of 2013, and in the past we have reported on the application of these techniques in outpatient lumbar spine surgery.^{6,8} We strongly assume that the transition to outpatient surgery (recently in Europe) follows exactly the same rules as those of ERAS. Following these first clinical trials, we report on our initial experience in applying an ERAS program to several degenerative spinal fusion procedures.

Methods

Type of Study

This is a retrospective analysis of prospectively gathered data from our institutional registry, which contains the records of all patients who underwent spinal fusion for degenerative conditions. The local ethics committee approved the study.

Definition of the Groups and Periods

At our institution, the ERAS approach has been implemented since the end of 2013, and the multimodal changes required at each pre-, intra-, and postoperative step have been established progressively. The different types of surgeries (lumbar disc herniation, decompression, anterior cervical discectomy and fusion [ACDF], other fusions, etc.) have been gradually included in the approach to facilitate the adoption of this paradigm shift by all stakeholders, including patients.

We devoted the current study to fusion procedures and selected two 2-year periods, the first from before any implementation of ERAS principles (pre-ERAS years 2012–2013) and the second corresponding to a period when the paradigm was applied widely (post-ERAS years 2016–2017).

We included in these periods all consecutive patients scheduled for three types of elective degenerative spine surgery with fusion: anterior lumbar interbody fusion (ALIF), ACDF, and any posterior or posterolateral fusion (posterior lumbar interbody fusion [PLIF], transforaminal lumbar interbody fusion [TLIF]), except in cases of scoliosis and large deformities that have not been considered suitable for the ERAS program at the moment.

ERAS Procedure

Preadmission and Preoperative Step

At our center, a 24-hour unit is dedicated to the support

of ERAS care, has trained nurses, and is a place in which a patient briefing session is held once the intervention is scheduled (Fig. 1).³³ The meeting with the surgeon is immediately followed by consultations with an anesthesiologist and physiotherapist (patient preoperative education). Then an ERAS nurse explains the pre- and postoperative stages of the procedure, as well as the prescribed home medication, and describes the main scenarios that can occur early after discharge. Nurses are on call to maintain a permanent telephone link with the patient at home. Before the patient is admitted to the hospital, he or she can consult online information about his or her future treatment and register online for hospital admission to limit excessive waiting the morning of his or her admission.

Hospitalization

Admission on the day of the procedure is made at 7 AM, with prescribed modern fasting and limited premedication. Prolonged fasting is avoided because it has been proven to exert negative effects on the metabolism and musculature. Eating is allowed until 6 hours prior to surgery, and clear liquids are permitted even up to 2 hours before, especially carbohydrate supplementation (e.g., apple juice).²¹ The transfer to the operating room is done by walking, without a stretcher.

Intraoperative Step

Discussions on indications and surgical techniques are outside the scope of this study, but, briefly, the techniques for all conditions were performed in the same manner in both periods. Nevertheless, our surgeons preferred minimally invasive techniques, whose basic concepts, particularly muscle sparing, are synergistic with the principles of ERAS.³⁶ All implants in lumbar posterior procedures were positioned under intraoperative 3D imaging and navigation. ALIFs were performed retroperitoneally with the support of a vascular surgeon, with the urinary catheter removed as soon as the operation was completed. The ACDFs were performed under a microscope via an anterior approach. The operators used either stand-alone polyetheretherketone (PEEK) cages or plates, according to the surgeon's preference and the patient's case. The use of drains was drastically limited, and the daily use of braces, lumbar belts, or soft/rigid cervical collars was not promoted except in exceptional cases. The patient typically spent 2 hours in the recovery room and received early advice from the rehabilitation team.

Postoperative Step

Discharge was rapidly organized in the following days after validation by the operator according to a checklist.⁵ Concerning pain control, the opioid-sparing multimodal approach was adopted by immediately favoring tramadol and nonsteroidal anti-inflammatory drugs in the recovery room.⁴ Oxycodone was provided if pain was poorly controlled by these other agents. Patient education was focused on the use of analgesics, with particular emphasis on avoiding the use of an opioid analgesic.²⁸ Regarding the early home follow-up, a nurse from the ERAS team was available 24 hours a day by phone or a dedicated mobile application (app).⁶

FIG. 1. Overview of ERAS procedures for spinal fusion for degenerative conditions. FT = fast-tracking (ERAS); H24 = 24-hour; OR = operating room; physio = physiotherapy; premed = premedication; QoL = quality of life.

Postoperative Management With Dedicated Mobile App

A dedicated mobile app (e-fitback, Nouvel e-santé) was used for the postoperative monitoring of patients in the post-ERAS group only. All consecutive patients had a smartphone, tablet, or personal computer (Fig. 2). During the preoperative consultation with ERAS nurses, a Quick Response (QR) code was given free of charge to the patient to load the app on the platform of his or her choice and for connection from 48 hours prior to surgery until the 15th postoperative day.

The mobile app recovery indicators included a visual analog scale (VAS) for pain and a questionnaire regarding body temperature, a painful voiding disorder, a motor disorder, or a blood stain on the dressing. The patient interface has a checklist that sends an alarm to the ERAS team with different color codes based on the information entered by the patient (Fig. 2). Patients must validate the checklist at least once during the first postoperative 48 hours; otherwise a nonresponse alarm is sent to the ERAS team, and the patient is immediately contacted. The frequency of use is unlimited during the 15 days.

The available alarms include the following: nonresponse alarm, triggered if the patient does not validate a checklist within the first 48 hours; green alarm, activated if the patient has a VAS score < 6, a fever < 38°C, no neu-

rological symptoms, or no blood stain on their dressing (this alarm does not trigger a specific reaction from the ERAS team); and emergency (red) alarm, activated if the patient has a VAS score > 6, a fever > 38°C, voiding difficulty, a new neurological deficit, or a blood stain on their dressing (this alarm triggers a reaction from the ERAS team, which contacts the patient quickly, 24 hours a day).

Outcome Assessment

A surgical consultation was routinely undertaken at 6 weeks postoperatively, during which neurological and pain statuses were recorded. Postoperative endpoints analyzed included death, systemic complications, wound complications (superficial wound infection, deep surgical site infection), and rehospitalizations at 90 days, which were considered as any surgical revision in this interval.²⁶ We used the classification proposed by Rampersaud et al.²⁵ to stratify complications into two groups: Major complications were defined as events requiring significant treatment, an increased LOS by > 7 days, long-term sequelae lasting > 6 months, or death. Minor complications were defined as events requiring no or minimal treatment, an increased LOS by 2–7 days, and no sequelae lasting > 6 months.

Any subsequent appointments were then based on clinical need.

FIG. 2. Mobile app dedicated to patient home monitoring (patient and nurse interface). Copyright Nouveal e-santé. Published with permission.

Satisfaction Survey

The mobile app was also used to conduct an online survey at the end of the e-health follow-up period in the post-ERAS group only. Five-point Likert scales (from 5 = very satisfied to 1 = very unsatisfied) were used to assess patient satisfaction, including satisfaction with 1) overall

care, 2) organization of discharge, 3) organization of stay preparation, and 4) the mobile e-health app in the perceived optimization of care management.

Statistical Analysis

Continuous variables are summarized as the mean ±

TABLE 1. Demographic data according to the two periods under study

Variable	Pre-ERAS (2012–2013)	Post-ERAS (2016–2017)	p Value
ALIF			
Sample size	159	202	
Age in yrs	44.5 ± 8.6	46.3 ± 10.7	0.58
Female	90 (56.6%)	99 (49.0%)	0.18
BMI in kg/m ²	25.2 ± 4.2	25.7 ± 6.1	0.31
ASA I	95 (59.7%)	129 (63.9%)	0.49
Tobacco	78 (49%)	79 (39.1%)	0.07
Multilevel surgery	24 (15.1%)	36 (17.8%)	0.58
ACDF			
Sample size	749	612	
Age in yrs	47.6 ± 9.9	48.7 ± 8.7	0.27
Female	342 (45.6%)	300 (49.0%)	0.23
BMI in kg/m ²	25.3 ± 5.1	27.3 ± 5.0	0.11
ASA I	427 (57%)	320 (52.3%)	0.09
Tobacco	382 (51.0%)	287 (46.9%)	0.14
Multilevel surgery	82 (10.9%)	104 (17.0%)	0.001
Pst lumbar fusion			
Sample size	655	1106	
Age in yrs	53.8 ± 14.3	56.1 ± 10.2	0.29
Female	326 (49.8%)	564 (51.0%)	0.65
BMI in kg/m ²	26.5 ± 4.0	27.3 ± 5.8	0.33
ASA I	306 (46.7%)	531 (48.0%)	0.63
Tobacco	321 (49.0%)	454 (41.0%)	0.001
Construct >2 levels	177 (27.0%)	351 (31.7%)	0.04

Pst = posterior.

Values expressed as the mean ± standard deviation or as frequency (percent).

Boldface type indicates statistical significance.

standard deviation or as the median (interquartile range). Categorical variables are summarized by frequencies and percentages. The mean LOS and rates of complications and revision surgeries at 90 days were compared using parametric tests (Student t-test and chi-square test, respectively). A p value < 0.05 was considered statistically significant. The analyses were undertaken using R (version 13.0, The R Foundation).

Results

Demographic Data

The complete population consisted of 3483 patients. The pre-ERAS group (2012–2013) included 1563 patients (159 ALIF, 749 ACDF, and 655 posterior fusion), and the post-ERAS group (2016–2017) included 1920 patients (202 ALIF, 612 ACDF, and 1106 posterior fusion). The comparative data concerning those groups are detailed in Table 1. There was no significant difference between groups among the ALIF patients in terms of age, sex, BMI, American Society of Anesthesiologists (ASA) classification, tobacco use, and uni- or multilevel procedures. Regarding the ACDF patients, the only significant dif-

ference between the period groups concerned multilevel procedures, which were more frequent in the post-ERAS period (17.1% vs 11.1%, p = 0.001). Among patients with posterior fusion, there were significantly fewer smokers (40.9% vs 49.9%, p = 0.001) and more multilevel procedures (31.7% vs 26.9%, p = 0.04) in the post-ERAS period.

ERAS Effect: Reduction in LOS

The mean LOS was significantly shorter in the post-ERAS group than in the pre-ERAS group for all three conditions (Fig. 3). LOS was reduced from 6.06 ± 1.1 to 3.33 ± 0.8 days for the ALIF group, from 3.08 ± 0.9 to 1.3 ± 0.7 days for the ACDF group, and from 6.7 ± 4.8 to 4.8 ± 2.3 days for the posterior fusion cases (for all comparisons: p < 0.001, Student t-test).

Complications

Complications data for the three types of procedures are presented in Table 2. There was no surgery-related death within 90 days after the index intervention. For ALIF patients, there was no significant difference in the rate of overall complications between the post-ERAS and pre-ERAS periods (11.4% vs 11.9%, respectively, p = 0.86), and there was no significant difference in the rehospitalization rate (3.0% vs 3.1%, p = 0.9) or revision rate (1.5% vs 1.8%, p = 1) at the third month after the index procedure. Likewise, for ACDF patients, there was no significant difference in the rate of overall complications between the post-ERAS and pre-ERAS periods (8.2% vs 6.0%, p = 0.12), and there was no significant difference in the rehospitalization rate (1.5% vs 2.1%, p = 0.36) or revision rate (0.8% vs 1.3%, p = 0.51) at the third month after the index procedure. For patients with posterior fusion, there was no significant difference in the rehospitalization rate at the third month after the index procedure (6.1% vs 8.1%, p = 0.12), but there was a significant decrease in overall complications in the post-ERAS period (10.9% vs 14.8%, p = 0.02), as well as in the surgical revision rate at month 3 (3.7% vs 6.1%, p = 0.03).

Postoperative Management After Discharge With the Mobile App

Mobile app data were available for 1627 patients from the post-ERAS group (131 ALIF, 490 ACDF, and 1006 posterior fusion). There were no reported technical software problems. During the 15-day period, 1420 patients (87.3%) did not trigger an emergency alarm, including 1410 patients who had completed their initial checklist within the first 48 hours (green alarm) and 10 patients who did not and thus triggered a nonresponse alarm and were contacted by the ERAS team. The latter patients showed no clinical abnormalities related to their recent surgery; 9 forgot to use the initial checklist and 1 had a defective smartphone. In the 15-day period, a total of 3962 green alerts among all patients were triggered, 97% of which were activated between 8 AM and 8 PM and 79.5% of which were triggered within the 1st week after discharge.

However, 207 patients (12.7%) triggered an emergency alarm, automatically provoking a phone call from the ERAS team. The ERAS team's median delay in returning

FIG. 3. Reductions in the LOS in the post-ERAS period. The y-axis represents the number of days. * $p < 0.001$.

a patient's call was 22 minutes (range 4–47 minutes). These 207 alarms were related to postoperative pain management and optimization of analgesics in 152 cases (73.4% of red alarms), a low-grade fever ($< 38.5^{\circ}$) in 30 cases (14.5%), a voiding delay in 9 cases (4.3%), and a problem with the surgical wound or dressing in 16 cases (7.7%).

The ERAS team managed the potential problems in 189 cases (91.3%) by a phone briefing on the optimization of analgesics or dressing, organized an earlier consultation with the referring surgeon in 16 cases (7.7%), and advised the patient to contact the emergency unit in 2 cases (1%).

Satisfaction Survey (Post-ERAS Group)

At the end of the mobile app monitoring period (15 days), an online survey was offered; 808 responses could be analyzed (Fig. 4). Concerning the satisfaction with overall care, 699 patients (86.5%) were satisfied or very satisfied. As regards the stay preparation, 750 patients (92.8%) were satisfied or very satisfied. Regarding the organization of discharge, 671 (83.0%) were satisfied or very satisfied, and concerning appreciation of the mobile e-health app in the perceived optimization of care management, 665 patients (82.3%) were satisfied or very satisfied.

Discussion

Study Findings

The introduction of ERAS at our institution for spinal fusion in the three studied conditions has resulted in a significant decrease in LOS without causing an increase in postoperative complications, and patient satisfaction with overall management, upstream organization of hospitalization, and the use of e-health is high. We even report a significant decrease in complications in the posterior fusion group. The range of average LOS in France (2017; from <https://www.atih.sante.fr/>) is 4.87–6.84 days for ALIF (our post-ERAS group: 3.33 ± 0.8 days), 2.8–4.91

TABLE 2. Complications after fusion spine surgery according to the two periods under study

Variable	No. (%)		p Value
	Pre-ERAS (2012–2013)	Post-ERAS (2016–2017)	
ALIF			
Sample size	159	202	
Overall complications	19 (11.9)	23 (11.4)	0.86
Minor complications	17 (10.7)	18 (8.9)	0.61
Major complications	2 (1.3)	5 (2.5)	
Rehospitalization <90 days	5 (3.1)	6 (3.0)	0.9
Revision surgery <90 days	3 (1.9)	3 (1.5)	1
Type of complication			
Medical	7 (4.4)	7 (3.5)	
Wound	5 (3.1)	7 (3.5)	
Neurological	2 (1.3)	3 (1.5)	
Dural leakage	0	0	
Implants	1 (0.6)	2 (1.0)	
Urinary tract infection	4 (2.5)	4 (2.0)	
ACDF			
Sample size	749	612	
Overall complications	45 (6.0)	50 (8.2)	0.12
Minor complications	29 (3.9)	31 (5.1)	0.28
Major complications	16 (2.1)	19 (3.1)	
Rehospitalization <90 days	16 (2.1)	9 (1.5)	0.36
Revision surgery <90 days	10 (1.3)	5 (0.8)	0.51
Type of complication			
Medical	8 (1.1)	13 (2.1)	
Cervical approach	20 (2.7)	17 (2.8)	
Implants	13 (1.7)	17 (2.8)	
Infection	4 (0.5)	3 (0.5)	
Pst lumbar fusion			
Sample size	655	1106	
Overall complications	97 (14.8)	121 (10.9)	0.02
Minor complications	54 (8.2)	77 (7.0)	0.03
Major complications	43 (6.6)	44 (4.0)	
Rehospitalization <90 days	53 (8.1)	67 (6.1)	0.12
Revision surgery <90 days	40 (6.1)	41 (3.7)	0.03
Type of complication			
Medical	10 (1.5)	29 (2.6)	
Wound	25 (3.8)	28 (2.5)	
Neurological	15 (2.3)	16 (1.4)	
Dural leakage	15 (2.3)	19 (1.7)	
Implants	26 (4.0)	22 (2.0)	
Urinary tract infection	6 (0.9)	7 (0.6)	

Boldface type indicates statistical significance.

days for ACDF (our post-ERAS group: 1.3 ± 0.7 days), and 3.79–8.42 days for posterior fusion (our post-ERAS group: 4.8 ± 2.3 days). According to our results, which are consistent with those in other studies, the whole concept of ERAS—primarily reducing complications and pain,

FIG. 4. Satisfaction survey conducted through a mobile app 15 days after patient discharge; 808 responses were analyzed.

and then reducing LOS¹⁹—seems applicable to spinal surgery.^{28,36}

Specificity of Spine Surgery

The development of ERAS protocols, first proposed for colorectal surgery more than 20 years ago by Kehlet, extends to all surgical disciplines.^{12,18,24,29} The general concept remains the same: reduce morbidity and improve the patient experience, which in turn will lead to a decrease in LOS and health cost savings. The pillars of ERAS are universal: 1) a proactive patient at the center of his or her management, 2) a combination of basic evidence-based care interventions to reduce pain and enhance recovery, 3) a multidisciplinary change in the organizational paradigm, and 4) a data-driven iterative improvement process.²¹ Wang et al. proposed very innovative approaches in two seminal papers concerning ERAS and lumbar fusion without gen-

eral endotracheal anesthesia.^{35,36} By institutional choice, however, we continue to use general anesthesia for posterior lumbar surgery, but we strongly support the authors' advocacy for a reduction in major analgesics and the expanded use of any minimally invasive technique.¹³ Importantly, spinal procedures are often associated with especially high levels of pain on the first postoperative day. Lumbar fusion and complex spinal reconstruction were among the six most painful procedures in the Gerbershagen et al.¹¹ study on pain intensity across 179 different surgical procedures. However, given the aging population, the demand for an improved quality of life, and the lack of efficacy or the exhaustion of alternative therapies, degenerative spinal fusion surgery is developing almost exponentially.⁹ ERAS can provide elements of optimization in a surgical field in which, unlike other specialties such as orthopedic joint surgery, spinal fusion surgery suffers from wide variabil-

FIG. 5. ERAS, a patient-centered perioperative concept. D0 = day 0.

ity in practitioners' indications and attitudes, as well as a high cost and very prolonged recovery.^{1,7,26,34}

Implementation of ERAS

It is always difficult to fight against conservatism and resistance to the adoption of new procedures or innovations, and ERAS is no exception.¹⁷ Resistance can be found at any level and concerns all stakeholders, from the administrative levels to the healthcare staff. Basic surgical routines such as drainage, the use of a collar or brace, the timing of discharge, the use of opioids, transport home in a personal car, and so on can vary greatly and significantly influence the LOS. Upstream collegial unification of procedures and protocols of care is an essential step in the development of ERAS.^{1,33} Optimizing the fluidity of the patient pathway is a prerequisite, as is the appropriate postoperative follow-up.³² The entirety of care is extended and improved even if the physical stay is shortened. The administrative formalities can be settled online before the procedure to allow an expedited admission of patients and to limit undue delay. The use of e-health is very promising, allows for personalized 24-hour monitoring, and does not force postoperative problems onto the general practitioner or external emergency services.^{6,14,27,31} The model we propose remains at an acceptable cost to our institution, which saves money by reducing the LOS.⁸

A Patient-Centered Approach

One of the pillars of ERAS is to make the patient proactive (Fig. 5). Measures that could be considered anecdotal (standing patient, mobile app, etc.) force the patient to position him- or herself dynamically throughout his or her care.¹⁸ Education provided before and during hospitalization is essential to ensure the patient's safety in terms of both the functional aspect of physical activities that he or she can resume early on and the management of analgesics at home.³

Involvement of All Stakeholders

In a world in which healthcare costs are becoming a major problem regardless of the system considered, the decrease in LOS, typically associated with lower costs, becomes particularly relevant.^{2,22} However, the patient puts the quality and safety of care before economic savings.

Historically, public authorities and payers have pushed caregivers to reduce LOS by emphasizing the economic side of controlling healthcare spending.³⁰ In our view, this may have created resistance among many physicians who did not want to put their patients at risk in a context of increasing medico-legal complaints. In the light of a growing scientific corpus, ERAS concepts make it possible to reverse this paradigm: Optimized protocols and high-level quality of care induce at least comparable clinical results, high patient satisfaction, and, as a second step, a decrease in LOS.¹⁹

If safety is assured with at least comparable clinical results—in a favorable medico-economic context—ERAS will have achieved its goal. And in the end, procedures in which all stakeholders (patients, physicians, administrators, and payers) are satisfied are not very frequent in the medical field.

Study Limits

Because of the progressive adoption of ERAS at our institution, our study was retrospective. We have tried to reduce this disadvantage by using a comprehensive and prospectively maintained database including a total number of interventions that appear relevant to achieving analyzable outcomes (3483 patients). It is quite obvious that despite the promising nature of applying the ERAS approach to spinal surgery, our study does not have the rigor of a randomized controlled trial, which we know is difficult to conduct in the field of elective degenerative spine surgery. Unlike evidence-based medicine, the practice of evidence-based surgery is hampered by inherent problems and obstacles.²³ At the moment, our approach does not apply to major surgeries (e.g., scoliosis, complex deformities) because of organizational issues. This is a work in progress, and other teams have started publishing on this subject.³⁴ Finally, our study does not include an economic component.³⁵ More detailed works will have to, on the one hand, establish the ERAS guidelines that do not yet exist for our discipline and, on the other hand, develop the medico-economic results.

Conclusions

Our study highlights the interest in applying ERAS protocols to fusion surgery for the degenerative spine. Our

initial hypothesis that a combination of basic evidence-based care interventions to enhance recovery will subsequently decrease morbidity and the need for hospitalization in the three spine conditions we have described seems to be confirmed. The central position of the patient is a key point in this paradigm shift, which affects all stakeholders in the healthcare chain. The literature is growing, with studies demonstrating the value of the fundamental pillars of ERAS, such as patient education, multimodal pain management, strategies to minimize blood loss, and early mobilization. Obviously, any analysis of ERAS results in spine surgery must take into account the specific degenerative pathology according to the chronicity of the painful condition before the operation, its affect on the functional quality of life, and the complexity and variability of the techniques used. The corpus of publications concerning ERAS and spine surgery, still in its infancy, is beginning to grow, which should make it possible to develop guidelines for the broad implementation of these protocols that are beneficial for patients, caregivers, institutions, and payers.

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Author Contributions

Conception and design: Debono, Corniola, Hamel. Acquisition of data: Debono, Pietton. Analysis and interpretation of data: Debono. Drafting the article: Debono. Critically revising the article: Corniola, Pietton, Sabatier, Hamel, Tessitore. Reviewed submitted version of manuscript: Debono, Sabatier, Hamel, Tessitore. Approved the final version of the manuscript on behalf of all authors: Debono. Statistical analysis: Debono, Pietton. Administrative/technical/material support: Tessitore. Study supervision: Debono, Hamel, Tessitore.

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