Gynecologic Oncology 154 (2019) 388–393

Contents lists available at ScienceDirect

Gynecologic Oncology

journal homepage: www.elsevier.com/locate/ygyno

Cost-analysis of Enhanced Recovery After Surgery (ERAS) program in gynecologic surgery

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HIGHLIGHTS

- Total cost saving during implementation period was $1'498'302.
- ERAS implementation in gynecology is cost-effective.
- ERAS remains cost-effective after implementation.

ARTICLE INFO

Article history:
Received 31 March 2019
Received in revised form 29 May 2019
Accepted 3 June 2019
Available online 13 June 2019

Keywords:
Gynecology
Surgery
Enhanced recovery
Cost
Sustainability

ABSTRACT

Objectives. Enhanced recovery after surgery (ERAS) programs has shown clinical benefits in gynecologic surgery. The aim of the present study was to compare costs before and after implementation of an ERAS program for gynecologic surgery.

Methods. Retrospective study comparing perioperative costs between consecutive patient groups undergoing gynecologic surgery (benign, staging or debulking) (I, 2012-13) prior, (II) immediately after, and (III, 2014-16) the three years after ERAS implementation. Preoperative, intraoperative, and postoperative real costs were collected for each patient *via* hospital administration. A bootstrap independent *t*-test was used for comparison.

Results. Demographics and preoperative characteristics were similar between group I ($n = 42$), II ($n = 51$), and III (ERAS I; $n = 122$, II; $n = 134$, III; $n = 90$). Average ERAS-specific costs were $687 per patient. Total mean individual costs per patient were $13′329 (95% confidence interval (CI): 11'301-15'213) and $17'710 (95% CI: 14′452–21′605) in the ERAS and pre-ERAS groups respectively, resulting in net savings of $4′381 (95% CI: 549–8'752, $p = 0.043$) in favour of ERAS group. Cost savings were explained by lower pre- and postoperative costs (difference: $5'011 95% CI: 1'587–8'998, $p = 0.019$).
Total costs continued to decrease by $2′520 (mean: $15'190, 95% CI: 13'791–16'631) in year 1, by $3'077 (mean: $14'633, 95% CI: 13'378–16'250) and $5'070 (mean: $12'640, 95% CI: 11'460–14'015) ($p = 0.03$) respectively, in year 2 and 3 after implementation.

Conclusion. Based on real costs and including specific costs due to ERAS implementation, ERAS program in gynecologic surgery induced significant decrease of overall costs by $4'381 per patient. Total costs continued to decrease in the three years after implementation.

1. Introduction

Enhanced Recovery After Surgery (ERAS) is a multimodal and multidisciplinary approach to reduce postoperative metabolic stress response by optimizing perioperative care [1]. These protocols led to significant improvements through a decrease of postoperative complications and length of stay in various fields of digestive surgery [2–4]. A review by Greer et al. analysing 25 randomized controlled trials in colorectal surgery reported a mean reduction in length of stay of 2.6 days

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https://doi.org/10.1016/j.ygyno.2019.06.004

(95%CI, −3.2 to −2.0) for the ERAS group compared to the non ERAS group. Risk ratio of perioperative morbidity was 0.66 (95% CI, 0.54–0.80). All-cause mortality and readmission rates at 30 days after surgery were similar [5]. Clinical outcomes are most important for patients and medical partners whereas cost efficiency is of general interest (hospital administrators, social security, insurances and politics) in the light of continuously rising healthcare costs. Cost analysis have shown significant cost savings after ERAS implementation for specific operations, such as colorectal procedures ($1'096 to 2'771 for cancer patients and $3'388 to 7'103 for non-cancer patients), cystectomy ($4'488), pancreatectomy (€7'657) or hepatectomy (€3'460) [6–9].

The aim of the present study was not only to analyse costs before and after ERAS implementation for gynecology but also to assess cost evolution in the following years.

2. Material and methods

ERAS program in gynecology was implemented in Lausanne University Hospital CHUV in October 2013. Training of the multidisciplinary team was provided by the Swiss ERAS centre of excellence by use of a formal training program endorsed by ERAS society (http://erassociety.org/). The ERAS protocol applied in gynecology was initially modified from the colonic surgery protocol until specific gynecology guidelines were available [10].

First period of inclusion of pre-ERAS patients ran from October 2012 to September 2013 (corresponding to the year prior ERAS implementation). After October 2013, all consecutive women undergoing elective gynecologic/oncologic surgery were included in the ERAS program. Patients for the present study were included until January 1, 2017. Since ERAS implementation, a dedicated database was prospectively maintained by a specially trained ERAS nurse. Data collected were patient's demographics, surgical details, complications, length of stay, and adherence to ERAS care items. Results regarding compliance to ERAS items have previously been studied [11]. During the investigation period from 2013 to 2017, except continuous day-to-day improvement, there was no significant implementation of new techniques or care protocols apart ERAS. Nurses and surgeons were trained to manage patient under ERAS protocols, but institutional usual training did not differ. No specific staff change happened during the study period.

Data were cross-checked every three months during systematic ERAS-gynecology meetings.

The study protocol was approved by the local review board (CER-VD # 2017-01996) and results were reported in accordance to the STROBE statements.

2.1. Main outcome measures

Perioperative care elements are described in ERAS for gynecologic/oncology surgery guidelines [12,13].

Demographic items included age, body mass index (BMI), smoking status, American Society of Anaesthesiology (ASA) group, diabetes. Surgical items included history of abdominal/pelvic surgeries, neoadjuvant chemotherapy, type of surgery (benign, staging *versus* debulking procedure), operating time (measured from skin incision to closure), surgical approach, differentiating minimally invasive procedures (laparoscopic and converted, according to the intention-to-treat principle) *versus* open surgery, and estimated blood loss.

Cost analysis was run based on previous cost-analysis studies [7,14]. Briefly, data regarding costs were obtained from invoicing department of our hospital, with actual costs and neither price charged to the patient's health insurance nor estimated costs. Costs were initially calculated in Swiss Francs (CHF). Exchange rate to US dollars ($) was CHF1 = $1.1 as on April 4, 2018. No adjustments for evolution of cost of life and inflation was done between the pre-ERAS and ERAS periods, but specific ERAS-program costs were also included.

2.2. Cost analysis - implementation

Costs included into analysis were allocated to intra- and pre-/postoperative categories. Intraoperative categories were anaesthesia and operating room (scrubbing nurse, anaesthesiologist clinical activity) and disposable materials. Pre-/postoperative categories were intensive care unit (ICU), intermediate care (IC), medical care (doctor's clinical activity in the OR and on the ward), nursing care (on the ward), physiotherapy, medication, blood perfusion, laboratory, radiology, pathology, housing, administration and finally other costs (social work, chaplain/priest, and occupational therapy costs). Regarding preoperative counseling and clinic time, the costs were included in the salary of the ERAS-dedicated nurse.

Pre-ERAS procedures were performed with no unified guidelines. No general guidance was available regarding pre-operative counseling, prehabilitation or bowel preparation. Intraoperative techniques, such as the use of drain and Foley catheter was at the surgeon's discretion. Postoperative care did not include systematic mobilisation of patient, drain/Foley removal, lab testing or a standardized analgesic protocol. Cost-minimization, defined here as analysis of most cost-effective method of surgical outcome while maintaining a desired level of quality, was performed. Running costs for ERAS program consisted in the ERAS nurse salary (20% part-time), ERAS meetings, licence cost for the ERAS Interactive Audit System (EIAS) database for data collection, patient personal paper logbook, and the preoperative carbohydrate drinks. Subgroup analysis of patients undergoing debulking procedures was performed.

2.3. Outcomes

Primary outcome was comparison of hospital costs before and after implementation of a gynecologic/oncologic ERAS protocol and evaluation of hospital costs over time after implementation.

2.4. Statistical analysis

Univariate analysis was performed with Mann-Whitney *U* test or Student *t*-test for continuous variables, depending on distribution type and variance homogeneity. For discrete categorial variables, Fischer's exact test or Chi-square test were used. Resampling *via* bootstrap method was performed for cost-analysis. Bootstrap t-test was used to compare different costs. *P*-value < 0.05 was considered statistically significant. To compare the evolution of costs in the 3 groups after ERAS implementation, a Kruskal-Wallis test was used.

Analyses were performed with SPSS_25 (IBM, Armonk, New York, USA) and GraphPad Prism_5.0 (GraphPad Software, Inc., La Jolla, California, USA).

3. Results

Overall analysis included 346 ERAS patients and 42 pre-ERAS patients. Analysis was performed including the costs of implementing ERAS program, with comparison between pre-ERAS patients ($n = 42$) and same period coverage after implementation ($n = 51$) (October 2012 to September 2013 and October 2013 to September 2014 respectively). Variation of costs for ERAS patients over 3 years was performed as well, with analysis of year 1 ($n = 122$), year 2 ($n = 134$) and year 3 ($n = 90$) after implementation. Demographic and surgical details are depicted in Table 1. Significant differences were remarkable for previous surgeries ($p = 0.041$) and type of procedures (benign *vs.* staging *vs.* debulking) ($p < 0.001$). All groups were similar in terms of perioperative outcomes, with median length of stay (LoS) for pre-ERAS and ERAS groups of 5 (interquartile range (IQR) 3–8) and 3 (IQR 2–4) days respectively ($p < 0.001$). No difference was found in terms of readmission rate (2.4% *vs.* 2.2, $p = 0.951$) and complications at 30 days (29% *vs.* 25%, $p = 0.698$) rates (Figs. 1a and 1b).

Table 1
Demographic and surgical details.

	Implementation			Evolution			
	Pre-ERAS ($n = 42$)	ERAS ($n = 51$)	P	ERAS year 1 ($n = 122$)	ERAS year 2 ($n = 134$)	ERAS year 3 ($n = 90$)	P
Age (median and IQR)	53 (45–66)	49 (44–57)	0.174	48 (45–55)	48 (44–58)	48 (43–54)	0.754
BMI (kg/m^2) (median and IQR)	24 (21–29)	26 (22–29)	0.316	25 (22–29)	26 (22–29)	26 (23−31)	0.280
Smoker, n (%)	11 (26)	12 (24)	0.767	15 (12)	28 (21)	19 (21)	0.132
ASA Group (1–2: 3–4) (%)	37 (88): 5 (12)	42 (82): 9 (18)	0.441	112 (93): 10 (7)	127 (94): 7 (6)	79 (88): 11 (1)	0.169
Diabetes (%)	1 (2.4)	6 (12)	0.088	8 (6.5)	6 (4.5)	0	0.156
Malignancy (%)	18 (43)	30 (59)	0.126	19 (16)	22 (16)	7 (8)	0.148
Previous surgeries, n (%)				4 (3)	15 (11)	10 (11)	**0.041**
Neoadjuvant chemotherapy, n (%)	8 (19)	7 (14)	0.514	11 (9)	16 (12)	6 (7)	0.408
Procedures, n (%)			0.135				
Benign	19 (45)	31 (60)		86 (70)	78 (58)	75 (83)	<**0.001**
Staging	20 (47)	11 (22)		28 (23)	47 (35)	12 (13)	<**0.001**
Debulking	3 (8)	9 (18)		8 (7)	9 (7)	3 (4)	0.512
Operating time (min) (median and IQR)	165 (128–236)	170 (120–291)	0.652	153 (118–221)	165 (132–219)	159 (129–202)	0.436
Minimally invasive approach, n (%)	22 (52)	34 (38)	0.161	88 (72)	94 (70)	65 (72)	0.921
Conversion to open, n (%)	10 (24)	22 (43)	0.279	11 (9)	10 (8)	3 (3)	0.261
Estimated blood loss (ml), (median and IQR)	300 (200–600)	300 (100–500)	0.219	200 (100−300)	200 (100–300)	200 (100–300)	0.603

Baseline demographic parameters of patient for A) Implementation-cost study: pre-ERAS (n = 42) and ERAS (n = 51) B) Cost evolution during Year 1 (n = 122), Year 2 (n = 134) and Year 3 (n = 90). BMI – Body Mass Index, ASA – American Society of Anaesthesiology, IQR – Interquartile Range. Age, BMI, operating time and intraoperative blood loss are presented in median ± IQR. All other are frequency and percentage. Bold *P*-values indicate statistical significance ($p < 0.05$). Costs are described in US dollars (USD).

3.1. Cost analysis - implementation

Cost minimization analysis is described in Table 2. ERAS specific fixed costs were salary of the 20% part-time ERAS dedicated nurse ($98'214 per year) and the costs of the ERAS-team meetings taking place 3 times a year ($60 per meeting, not including salaries from medical staff attending the meetings). Total fixed costs over implementation year were then $19′823 (98′214 × 0.20 + 60 × 3).

Variables running costs per patients included maintenance of ERAS database (ERAS Interactive Audit System - EIAS) ($120/patient), carbohydrate drinks ($90/patient) and patient logbook ($4.8). Total variable costs over implementation year were then $9'022 (120 × 42 + 90 × 42 + 4.8 × 42).

Average ERAS-specific costs were $687 per patient ((19'823 + 9'022)/42).

Mean costs for each administrative item are shown in Table 3. Total mean individual costs per patient were $13'329 (95% CI: 11'301–15'213) and $17'710 (95% CI: 14'452–21'605) in the ERAS and pre-ERAS groups respectively, leading to a mean difference per patient of $4'381 (95% CI: 549–8'752, *p*-value: 0.043) in favour of the ERAS group. With $4'381 cost saving per patient in 342 patients, the total cost saving during the study period was $1'498'302.

3.2. Cost analysis - evolution

Mean individual costs by administrative subdivisions are shown in Table 4 for cost-evolution over time. Intraoperative costs decreased from $6'180 (95% CI: 5'751–6'620) to $6'000 (95% CI: 5'563–6'430) and to $5'727 (95% CI: 5'301–6'164) from year 1 after implementation to year 2 and to year 3 respectively (*p*-value: 0.501).

Pre-/postoperative costs decreased from $9'010 (95% CI: 8'030–10'115) to $8'634 (95% CI: 7'519–9'887) to $ 6'889 (95% CI: 5'956–8'098) from year 1 after implementation to year 2 to year 3 respectively (p-value < 0.001).

Total mean overall costs were $15'190 (95% CI: 13'791–16'631) during the first ERAS year and decreased to $14'633 (95% CI: 13'378–16'250) the second ERAS year and to $12'640 (95% CI: 11'460–14'015) the third ERAS year (p-value: 0.03).

The subgroup analysis of debulking patients revealed the following results: For implementation group analysis, readmission rates after

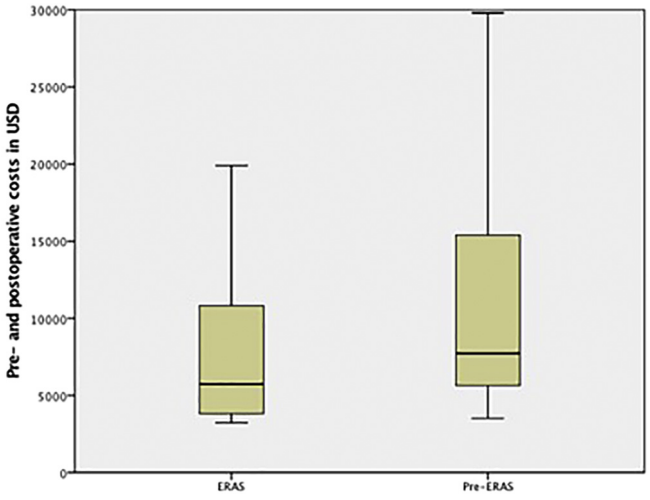

Fig. 1a. Pre- and postoperative mean cost differences between pre-ERAS *vs.* ERAS for implementation. ($p = 0.019$, Kruskal-Wallis test comparing the 3 groups).

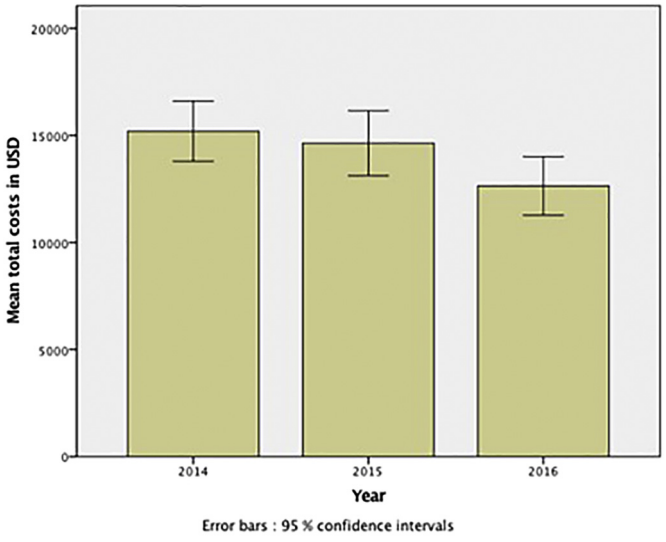

Fig. 1b. Total mean cost evolution over time ($p = 0.03$, Kruskal-Wallis test comparing the 3 groups).

Table 2
Cost minimization analysis per patient during implementation.

	ERAS (n = 51)	Pre-ERAS (n = 42)	Mean difference[b]
ERAS-specific costs	687	0	687
Intraoperative costs[a]	5567	4938	629
Pre- and postoperative costs[a]	7762	12,772	-5010
Total costs	14,016	17,710	-3694

[a] Mean costs in US dollars (USD) and 95% confidence intervals.
[b] ERAS minus pre-ERAS.

debulking were 0/3 (0%) in pre-ERAS and 0/9 (0%) in ERAS groups ($p > 0.05$). Overall mean costs were $35'842 (95% CI: 13'226–61'242) in pre-ERAS and $18'971 (5'460–31'971) in ERAS groups ($p = 0.092$).

Regarding evolution group analysis, readmission rates after debulking were 0/8 (0%) in year 1, 0/9 (0%) in year 2 and 0/3 (0%) in year 3 ($p > 0.05$). Overall mean costs for year 1, 2 and 3 were $28'730 (5'460–45'897), $27'949 (16'752–61'095) and $28'765 (9'387–43'048), respectively ($p = 0.592$).

4. Discussion

The present study revealed substantial cost benefits of ERAS implementation in gynecologic surgery. Not only did savings occur immediately after implementation, but were maintained over years after implementation. In total, $4'381 were spared for each patient between pre- and post-ERAS period, which lead to a total cost saving of over $1.4 million during the study period. The interest of such an ERAS program is not only the sustainability of both decrease in cost per patients and savings, but the positive clinical outcomes after ERAS implementation in gynecologic oncology as described by several studies (lower postoperative complications, mortality and readmission rates and reduced LoS [15–17].

Sub-analysis of cost expenditures for implementation showed a higher impact of pre-and post-operative items (Table 3). In the present study, ERAS was associated with significant lower costs in ICU, nursing care, administration and miscellaneous pre-/postoperative costs. No statistical difference was found in terms of intraoperative costs, nor pre-/postoperative costs (medical care, physiotherapy, medication, blood, laboratory, radiology, pathology and housing). Most of the savings were achieved through a decrease in medical costs, mainly because of standardization of care. Workload reduction has been demonstrated in colorectal patients, but this remains to be determined in gynecology [18]. Another source of savings was the decreased use of ICU [19]. Similar to our findings, Gerardi et al. observed a reduction of hospital costs by $5'410 per patient [20]. Furthermore, the results of the present study are in line with findings in colorectal, hepato-biliary, thoracic or ear-nose-throat (ENT) surgeries [7,14,21–23]. In these areas ERAS pathways proved to be cost-beneficial, partly due to decreased complications. Large-scale savings could also be achieved through wide-scale implementation of ERAS within the entire provincial healthcare system of Alberta, Canada [24].

Cost-efficiency for single interventions in gynecology, such as benign vaginal hysterectomy, has been studied in a case-control study, with a decrease in cost of around 15% [25]. Another study in general gynecology found a decrease in cost of around 18% when including staging procedures and cytoreductive surgeries [26]. In major procedures, the effect of ERAS on cost is even more apparent due to the inherent significant burden of morbidity/mortality and related costs. Literature comparing costs of enhanced recovery program in gynecology is scarce. Many articles reported on short-term benefits, as those are considered to be easily quantifiable. Cost-effectiveness of ERAS in other fields of surgery has been revealed by various authors, mainly in colorectal surgery. Those studies focused on early implementation phase of ERAS protocols [7,27,28]. Lee et al. performed a systematic review on the costs of ERAS in colorectal surgery (ten articles retained, mainly prospective cohorts). Results showed that only one study included the implementation and maintenance costs of ERAS, with differences in results regarding cost benefits of ERAS implementation (American studies reported significantly lower direct medical costs, but two of the four European studies did not demonstrate any decreased costs). Sustained cost-analysis over several years has not been performed yet, even in the field of colorectal surgery where ERAS has been extensively studied.

The present study revealed sustained cost-efficiency with decreased mean costs over three years after implementation (Table 4). Potential explanations for reduced costs include the standardization of the procedures, the acquisition of ERAS pathway as (good) habit and high compliance with the protocol, even though not specifically assessed in this present study. Continuous training of teams, especially nursing and medical teams [29,30], is mandatory to maintain both high compliance and cost savings over time [2]. Complications and LoS have been shown to be directly correlated with compliance to ERAS protocol [11,31]. Persistence of benefits over time may be explained by high compliance to pre-, intra- *and* post-operative ERAS items, with teams more accustomed to the "enhanced recovery way" of managing patients. Another

Table 3
Mean individual costs by administrative subdivision for ERAS and pre-ERAS groups.

	ERAS			Pre-ERAS						
	Mean	Inferior CI	Superior CI	Mean	Inferior CI	Superior CI	Mean difference	Inferior CI	Superior CI	P-value
Total intraoperative	**5 567**	4 784	6 337	**4 938**	4 414	5 499	**-630**	-1 583	360	0.201
Anaesthesia and operating room	5 177	4 444	5 915	4 600	4 142	5 143	-577	-1 490	333	0.226
Disposable materials	391	281	516	338	207	548	-53	-236	186	0.646
Total pre- and postoperative	**7 762**	6 504	9 013	**12 772**	9 670	16 361	**5 011**	1 587	8 998	*0.019*
ICU/IC	0	0	0	1 402	571	2 305	1 402	571	2 305	*0.028*
Medical care	1 933	1 654	2 243	3 154	1 998	4 716	1 220	-12	2 820	0.131
Nursing care	2 199	1 707	2 658	4 018	2 955	5 405	1 819	570	3 279	*0.039*
Physiotherapy	32	3	79	91	42	141	59	-5	120	0.073
Medication	67	39	103	134	78	203	66	1	138	0.076
Blood	163	103	230	167	104	250	3	-93	107	0.953
Laboratory	99	56	150	247	134	393	148	22	295	0.068
Radiology	24	4	54	118	36	223	94	4	201	0.111
Pathology	1 764	1 356	2 200	1 909	1 531	2 353	146	-455	774	0.631
Housing	1 043	859	1 249	1 153	816	1 535	110	-298	558	0.613
Administration	421	418	423	401	396	406	-21	-27	-14	*0.001*
Others*	16	13	19	37	27	51	21	10	35	*0.044*
Total	**13 329**	11 301	15 213	**17 710**	14 452	21 605	**4 381**	549	8 752	*0.043*

Costs are described in US dollars (USD). ICU: intensive care unit, IC: intermediate care, CI: 95% confidence interval. Italic p-value indicates statistical significance.
* Others include the social work, the chaplain/priest, and the occupational therapy costs.

Table 4
Mean individual costs by administrative subdivision per year after implementation.

	ERAS year 1			ERAS year 2			ERAS year 3			
	Mean	Inferior CI	Superior CI	Mean	Inferior CI	Superior CI	Mean	Inferior CI	Superior CI	P-value
Total intraoperative	**6180**	5751	6620	**6000**	5563	6430	**5727**	5301	6164	0.501
Total pre- and postoperative	**9010**	8030	10,115	**8634**	7519	9887	**6889**	5956	8098	***<0.001***
Total	**15,190**	13,791	16,631	**14,633**	13,378	16,250	**12,640**	11,466	14,015	***0.03***

Costs are described in US dollars (USD).

explanation may come from motivated patients choosing an ERAS hospital rather than a non- ERAS facility.

Several limitations of the present study need to be addressed. The retrospective assessment of pre-implementation group may have led to missing data. Groups for analysis were not perfectly matched, as they differed for procedure indications (benign-staging-debulking) and for number of previous surgeries. The study cohort and surgical indications were heterogeneous with inclusion of both benign and malignant underlying pathologies. This has to be considered when interpreting the results. To address this, subgroup analysis for debulking patients was made, which however was limited by the small event rate. One could argue that savings made during in-hospital stay are transferred (or postponed) to out-hospital care, such as rehabilitation centers and home care. However, as respective data was not available and thus this assumption remains hypothetical. Further studies, however, should focus on post-hospitalization costs to clarify this point. Costs of implementation such as time to ERAS start (transition) and physician and staff education were not included, as it was impossible to have precise cost data for these items. Furthermore, it was impossible to capture costs associated with post-discharge emergency room visits and related costs were therefore not included in this study. Regarding complications at 30 days post-discharge and readmission rate, it is possible that patients were readmitted to other hospitals after discharge from our institution (potential loss to follow-up). Data regarding cost of such events were not available. This might have further contributed to an underestimation of the actual costs. Results of the present single-centre study need independent confirmation. Finally, cost analysis for ERAS is not universally standardized in terms of cost assessment method and types of included costs. The used methodology is nevertheless precisely described by several other studies [7,8].

5. Conclusion

Implementation of ERAS in gynecologic surgery induced a significant and sustained decrease of overall costs during the first three years after implementation. This study showing financial benefits over time provides a positive economic argument to stakeholders and policy makers in favour of ERAS implementation. Development of hospital practice in an equitable and rational way in the future will be the rule rather than the exception.

Disclosure of Competing Interest

None to be declared.

Ethical approval

Approved by the local review board “Commission Cantonale d'éthique Vaud” (CER-VD # 2017-01996).

Funding

The authors declare to have neither source of support nor funding for this work.

Quick resumé

Enhanced recovery after surgery (ERAS) has been shown to reduce complications and hospital stay through multimodal care. This study assessed cost-effectiveness of ERAS for gynecology and revealed USD 4'381 savings per patient after implementation, and sustained cost reductions during the 3 following years.

Author's contributions

BP, GRJ: conception and design, analysis and interpretation, drafting
MH, FG: design, analysis and interpretation, critical revision
ND, PM: analysis and interpretation, critical revision
CA: conception and design, analysis and interpretation, drafting
All authors read and approved the final manuscript.

The authors would like to acknowledge the support provided by all members of the ERAS team in Lausanne, especially of the ERAS-dedicated nurses Mona Schäppi and Valérie Addor.

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