

The Financial Impact of Increasing Surgical Complexity: Contribution of Sugammadex as Safer Choice for Neuromuscular Blockade Reversal in an Ambulatory Surgical Center

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Received date: June 07, 2018; Accepted date: July 02, 2018; Published date: July 06, 2018

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Abstract

Introduction: Several surgical procedures may have efficiency gains with the ambulatory methodology. Patient comorbidities control is key for successful procedures. Anesthetic drugs and neuromuscular blockade reversal strongly contribute to patient safety and satisfaction, allowing evolution to more complex procedures.

Purpose: This study evaluated the financial impact on hospital annual income, when transitioning some surgical procedures from inpatient to ambulatory surgical program, with anesthesiology department assentment.

Methods: A risk-adjustment method, based on a logistic regression model, calibrated with approximately 1.15 million episodes from Spanish and Portuguese hospitals was used. A list of procedures performed in Centro Hospitalar do Porto was subject to classification with the label ('Yes', 'No' or 'Maybe') regarding the possibility for ambulatory surgery, relying on sugammadex safety.

Results: A total of 153 procedures were classified as 'Yes' or 'maybe' (n=16,944 inpatient episodes), in 2014. 73.4% of these episodes were already performed in ambulatory, but it was expected to reach 85.5%. Assuming a consumption of at least 1 inpatient day for each potentially ambulatory episode, an overconsumption of at least 2,044 inpatient days in 2014 was forecasted. The potential financing gain in 2014 would be 4.59 Million Euros.

Discussion: To safely ambulatorize and improve revenue, not only patient selection must be optimized, but also safe routines and choices of correct short acting drugs (propofol, rocuronium), and definitive drug reversal policies (sugammadex), must be implemented.

Conclusions: To ambulatorize some inpatient surgical procedures increased both case-mix values. These increased complexity values have a direct positive impact on the hospital income.

Keywords: Sugammadex; Ambulatory surgery; Surgical case-mix

Introduction

The classic model for hospital-programmed surgery with ward admission has evolved during the last decades to an ambulatory or outpatient basis [1]. Improvements in anesthesia with new analgesics for the relief of pain, and the development of minimally invasive procedures (such as laser surgery, laparoscopy, and endoscopy) contributed greatly to these findings [1].

Evidence has been gathered about the cost-effectiveness of ambulatory surgery when compared to inpatient methodology; general surgery, namely cholecystectomy [2] or hernia repair surgery [3], orthopedic surgery [4,5], vascular surgery [6] are some examples of surgeries with major efficiency gains accomplished with the ambulatory surgery methodology.

A frequent and important concern when organizing an ambulatory surgery program is linked to the complexity of the procedure, with its possible side effects, namely excessive postoperative pain, perioperative bleeding or any surgical related situation that may contraindicate the feasibility of that type of surgery on the ambulatory setting. In this regard, several studies and reports have been published showing that even alleged complex procedures that would not be thinkable for ambulatory surgery are nowadays being done on this basis, namely spine surgery [7,8], maxillofacial [9], gynecology [9], laser micro laryngeal surgery [10] amongst others.

Likewise, patient selection has also been part of the concern and guidelines have been issued regarding this topic [9,11]. Comorbidities must be taken into account and the patient fit condition is of paramount importance for the success of the procedure. Frequently when comorbidities are not fully addressed on admission, clinical complications often emerge.

The choice of the anesthetic drugs, ventilation mode, intra and postoperative analgesic plan, postoperative nausea and vomiting (PONV) control strategy also contribute to reduce failure rates and to increase patient satisfaction and safety, allowing surgical teams to evolve to more complex procedures [12]. Short acting agents either hypnotics, analgesics, or neuromuscular blockers are the drugs of choice [12]. Drugs with fewer side effects are also logical and wise choices, as for example it seems prudent to avoid neostigmine and prefer sugammadex to revert the neuromuscular blockade, due to its ability to (a) reduce the risk of PONV [12], and (b) to fully reverse the blockade with less probability of the occurrence of residual paralysis, and consequently less probability of occurrence of postoperative pulmonary complications [13-15]. In addition, some evidence has been showing that this type of reversal, with sugammadex, correlates with better operating room management, evidenced by shorter operating room turnaround time, and shorter recovery periods [10].

Purpose of the Study

The purpose of this study was to evaluate the financial impact on hospital annual economical income, when transitioning some surgical procedures from inpatient to ambulatory setting, giving a previous clinical selection made by the Anesthesiology Department regarding a safe intraoperative procedure and postoperative recovery.

Key Points for Study Enrolment

The mentioned clinical selection made by the Anesthesiology Department intended to identify several inpatient surgical procedures as possible surgeries to be performed as ambulatory interventions at Centro Hospitalar do Porto, considering the minimization of occurrence of postoperative nausea and vomiting, postoperative residual paralysis and pulmonary complications, and the utilization of any level of neuromuscular block (NMB) with the correspondent safer surgical fields, (assuming the reversal of NMB with sugammadex and NMB monitoring to all patients).

This study was carried out by IASIST[®] and the Anesthesiology Department of Centro Hospitalar do Porto (CHP). It should be interpreted as a theoretical model, which aims to estimate the impact produced by the change of certain inpatient surgical procedures to an ambulatory surgery facility in CHP. The appropriate patients' and surgical procedures selection, the use of specially tailored drugs for the ambulatory surgery anesthesia setting, namely short acting hypnotics, analgesics, and NMB with the neuromuscular-blocking reverser sugammadex, were focused on 4 years of clinical activity of Centro Hospitalar do Porto, from 2011 to 2014, in order to accomplish the purpose of the study.

Concepts

Hospital financing and case-mix

The current financing model for Portuguese National Health Service (NHS) hospitals is based on a Prospective Payment System (PPS) using the Diagnosis-Related Groups (DRGs) [16]. The DRGs are a Patient Classification System used to categorize clinical episodes with similar consumption of resources [17]. The DRGs are used in three major hospital production lines: Inpatient, Ambulatory Surgery and Medical Ambulatory. Each patient episode treated in one of these production lines is classified into one DRG.

The classification into a DRG is made using a set of clinical (main and secondary diagnoses, surgical interventions) and non-clinical variables (age, sex, destination after discharge), which are gathered during the episode [17,18]. Each DRG has a relative weight, based on the estimated costs assessed by the hospital services, as well as a minimum and maximum threshold of inpatient days. The average weight of the DRGs produced in the hospital, corrected by their inpatient days thresholds, is called the Case-Mix Index (CMI) [16].

The public entity responsible for financing the Portuguese NHS hospitals-Administração Central do Sistema de Saúde (ACSS)-annually publishes a Base Rate for hospital financing which, alongside with de Case-Mix Index of each hospital, is used to calculate the value the hospital will charge for the production of that year [16]. The formula to calculate the yearly hospital financing is, as follows:

$$F_{h,p} = N_{h,p} \times BR \times CMI_{h,p}$$

$F_{h,p}$ = Financing of the production line p in hospital h

$N_{h,p}$ = Number of episodes of the production line p in hospital h

BR = Base Rate for hospital financing

$CMI_{h,p}$ = Case-mix Index of the production line p in hospital h

As an example, the financing of the Inpatient production line in Hospital H, with 25,000 episodes discharged in 2014, considering a Base Rate of 2,120.28€ and a Case-mix Index of 1.4, would be as follows:

$$F_{H,inpatient} = N_{H,inpatient} \times BR \times CMI_{H,inpatient} = 25,000 \times 2,120.28€ \times 1.4 = 74,209,800.00€$$

Ambulatory surgery

The International Association for Ambulatory Surgery (IAAS) defines two distinct concepts in what concerns Ambulatory Surgery [19].

True Ambulatory Surgery (without overnight stay)-The patient is subject to a surgical procedure in hospital setting and discharged in the same day of the admission. In this case, the patient does not occupy a hospital bed.

Extended Recovery (with overnight stay)-The patient is subject to a surgical procedure in hospital setting and discharged within twenty-four hours after the admission. In this case, the patient may occupy a hospital bed.

In the context of this study we will only refer to the Extended Recovery concept, since it is the one currently accepted by the Portuguese NHS.

Methods

The initial project of this study has been presented to the Administration Board of Centro Hospitalar do Porto-Portugal in the first projecting phase; after extensive revision of suitability by the authors, it was again presented to the Administration Board with subsequent review and approval and authorization by the President and Chief Executive Officer from the Centro Hospitalar do Porto, Portugal, the person entitled for this task, with the approval number 01-11/05/018. Regarding this type of study, the authors considered this to be a normal process of approval.

The model

In order to evaluate the potential of ambulatory surgery in Centro Hospitalar do Porto we used a risk-adjustment method, based on a logistic regression model calibrated with approximately 1.15 million episodes from Spanish and Portuguese NHS hospitals.

In order to be considered potentially ambulatory, a procedure needs to be performed in ambulatory setting, in at least 5 hospitals, with a minimum volume of 50 episodes per hospital. This results in 798 identified procedures/combinations of procedures, which are then grouped, using a proprietary clinical and statistical criteria, into 205 groups of potentially ambulatory procedures.

The risk-adjustment model is then applied to each episode in order to measure the probability of undergoing a specific surgical procedure in ambulatory setting, considering the individual characteristics of the patient, including the associated co-morbidities and/or complications. The following episodes are excluded from the model:

- Episodes with 0 inpatient days, transferred to another hospital
- Episodes of newborns
- Episodes with inpatient time above 6 months
- Episodes with 0 inpatient days with DRG without ambulatory price defined.

The potentially ambulatory episodes are then identified from the clinical practice of the best performers (Benchmark), which corresponds to the 25-percentile of the episodes that already perform those procedures in ambulatory setting.

Finally, only the procedures that according to the clinical staff of Centro Hospitalar do Porto are eligible to be performed in ambulatory setting were selected. For this purpose, a list of all groups of procedures performed in Centro Hospitalar do Porto was subject to validation and classified with the label ('Yes', 'No' or 'Maybe') in what regards the possibility of substitution inpatient surgery by ambulatory surgery, attending the clinical setting of correct ambulatory clinical routines, anesthetic drug choice and most important, specific strategies to decrease the possibility of occurrence of key features that precludes the

success of the surgical procedures in the ambulatory set up (i.e. postoperative nausea and vomiting, uncontrolled pain, residual paralysis). Based on this classification we analyzed two different scenarios:

- Scenario A: The substitution occurs only for those episodes classified with 'Yes' (more conservative analysis)
- Scenario B: The substitution occurs for the episodes classified with 'Yes' or 'maybe' (less conservative analysis)

Taking into account the adjustment model in each scenario, all the potentially ambulatory episodes and their respective DRGs were identified. We then recalculated the complexity indices of Centro Hospitalar do Porto, both from Inpatient and Ambulatory Surgery, by replacing all the potential ambulatory episodes for Ambulatory Surgery.

Data sources

The data sources used for this study are the hospital morbidity databases (DRGs databases) of Centro Hospitalar do Porto, from 2011 to 2014. The DRG version used for the analysis is the AP-DRG version 27. The Base Rate for hospital financing considered in each year is the one defined in each year's contract-program, made available by ACSS.

Results

Hospital production

Between 2011 and 2014 there was a very significant increase in the number of ambulatory surgery episodes and a decrease, yet slower, in the number of inpatient episodes (Table 1). There is, however, a significant slowdown in the variation of the Ambulatory Surgery activity, with a deceleration of the variation from 14.1% (between 2011 and 2012) to 1.3% (between 2013 and 2014). The Base Rate for hospital financing has suffered a reduction of approximately 8% between 2011 and 2014 (Table 1).

Year	Inpatient Episodes	Inpatient Variation (Year/Year-1)	Ambulatory Episodes	Ambulatory Surgery	Ambulatory Surgery Variation (Year/Year-1)	Total Variation (Year/Year-1)	Base Rate (€)
2011	31,576	-	12,295	-	-	-	2,300.40
2012	30,718	-2.7%	14,028	14.1%	0.4%	0.4%	2,116.37
2013	30,323	-1.3%	15,498	10.5%	3.8%	3.8%	2,141.70
2014	29,844	-1.6%	15,701	1.3%	1.0%	1.0%	2,120.28

Table 1: Evolution of the production in Centro Hospitalar do Porto and Base Rate.

Year	Episodes (51 selected surgical procedures)	Ambulatory Surgery Observed	Ambulatory Surgery Expected	Ambulatory Surgery Observed Rate	Ambulatory Surgery Expected Rate	Impact (Episodes)
2011	4,955	2,532	3,534	51.1%	71.3%	-1,002
2012	4,907	2,652	3,603	54.0%	73.4%	-951
2013	4,911	2,595	3,578	52.8%	72.9%	-983

2014	4,859	2,552	3,515	52.5%	72,3%	-963
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Table 2: Scenario A: Ambulatory Surgery Impact in Centro Hospitalar do Porto.

Scenario A-procedures classified with 'Yes': In Scenario A, 51 procedures were classified with 'Yes'. This represented 4.859 clinical episodes in 2014. 52.5% of these episodes are already performed in Ambulatory when the expected rate, according to the model, would be 72.3%. This difference represents an impact of less 963 Ambulatory Surgery episodes compared to what was expected. The impact decreased by 39 episodes between 2011 and 2014 (Table 2). Assuming a consumption of at least 1 inpatient day for each potentially ambulatory episode, this result represents an overconsumption of at least 963 inpatient days in 2014.

The top-10 procedures with the biggest impact in 2014 would, alone, cover 705 episodes (73%) of the total Impact (Table 3).

Procedure	Impact (Episodes)
Submucosal resection of the nasal septum	-170
Inguinal hernia repair	-142
Excision or destruction of the uterus	-96
Destruction or bilateral endoscopic occlusion of the fallopian tubes	-65
Excision, destruction of injury, pharyngeal tissue or other pharyngeal interventions	-49
Sinusectomy or other procedures on nasal and perinasal sinuses	-44
Unilateral orchiectomy or orchiopexy	-42
Umbilical hernia repair	-36
Closed biopsy of uterus or other diagnostic procedures	-32
Laparoscopic marsupialization of ovarian cyst	-29

Table 3: Scenario A: Procedures with the biggest Impact in 2014.

The transfer of the potentially ambulatory episodes from the Inpatient activity to Ambulatory Surgery would represent, in 2014, a 2.3% increase in the Inpatient Complexity Index (Table 4). As a result,

Year	Episodes (153 selected procedures)	Ambulatory Surgery Observed	Ambulatory Surgery Expected	Ambulatory Observed Rate	Ambulatory Expected Rate	Impact (Episodes)
2011	13,898	9,305	11,543	67.0%	83.1%	-2,238
2012	14,650	10,316	12,389	70.4%	84.6%	-2,073
2013	16,295	11,863	13,942	72.8%	85.6%	-2,079
2014	16,944	12,439	14,483	73.4%	85.5%	-2,044

Table 5: Scenario B: Ambulatory Surgery Impact in Centro Hospitalar do Porto.

The transfer of the potentially ambulatory episodes, from the Inpatient activity to Ambulatory Surgery would represent, in 2014, a

5.1% increase in the Inpatient Complexity Index (Table 7). As a result, in the Inpatient activity alone, the potential financing gain in 2014 would be 2.11 Million Euros. This transfer would also represent a residual increase of 0.2% of the Ambulatory Surgery Complexity Index and a potential financing gain in the Ambulatory Surgery activity of 628 Thousand Euros. The combined potential gain of the Inpatient and Ambulatory Surgery production lines would be approximately 2.74 Million Euros in 2014.

	Year	Complexity Index Observed	Complexity Index Expected	Complexity Index Variation	Potential Financing Gain (€)
Inpatient	2011	1.3422	1.3741	2.4%	2,315,142.38
	2012	1.3868	1.4184	2.3%	2,051,828.49
	2013	1.4077	1.4409	2.4%	2,156,685.73
	2014	1.4353	1.4687	2.3%	2,114,924.18
Ambulatory Surgery	2011	0.4657	0.4585	-1.5%	790,229.08
	2012	0.4213	0.4198	-0.3%	606,614.41
	2013	0.4187	0.4186	0.0%	648,113.71
	2014	0.4166	0.4175	0.2%	627,966.76

Table 4: Scenario A: Complexity Index and potential Financing Gain in Centro Hospitalar do Porto.

Scenario B-procedures classified with 'Yes' or 'maybe': In Scenario B, 153 procedures were classified with 'Yes' or 'maybe'. This represents 16,944 inpatient episodes in 2014. 73.4% of these episodes are already performed in Ambulatory when the expected rate was 85.5%. This difference translates into an impact of less 2,044 episodes of Ambulatory Surgery compared to what was expected. Like in Scenario A, this impact also decreased between 2011 and 2014 (Table 5). Assuming a consumption of at least 1 inpatient day for each potentially ambulatory episode, this result represents an overconsumption of at least 2,044 inpatient days in 2014.

The top-10 procedures with the biggest impact in 2014 would, alone, cover 870 episodes (43%) of the total Impact (Table 6).

would be 4.59 Million Euros. This transfer would also represent a residual increase of 0.8% of the Ambulatory Surgery Complexity Index and a potential financing gain in the Ambulatory Surgery activity of 1.35 Million Euros. The combined potential gain of the Inpatient and Ambulatory Surgery production lines would be approximately 5.94 Million Euros in 2014.

Discussion

According to the model and despite already having high Ambulatory Surgery rates, Centro Hospitalar do Porto still has potential for improvement.

Procedure	Impact (Episodes)
Submucosal resection of the nasal septum	-170
Inguinal hernia repair	-142
Excision or destruction of the uterus	-96
Incision and excision of the muscle, tendon or fascia	-76
Repair of retinal detachment	-69
Surgeries or diagnostic procedures in the vitreous, retina, choroid and posterior chamber of the eye	-67
Destruction or bilateral endoscopic occlusion of the fallopian tubes	-65
Removal of foreign body from the vitreous, with vitrectomy	-65
Meniscectomy	-62
Corneal transplantation	-58

Table 6: Scenario B: Procedures with the biggest Impact in 2014.

	Year	Inpatient Complexity Index Observed	Inpatient Complexity Index Expected	Inpatient Complexity Index Variation	Inpatient Financing Potential Gain (€)
Inpatient	2011	1.3422	1.4118	5.2%	5,057,682.22
	2012	1.3868	1.4548	4.9%	4,421,750.95
	2013	1.4077	1.4781	5.0%	4,568,922.36
	2014	1.4353	1.5078	5.1%	4,587,084.66
Ambulatory Surgery	2011	0.4657	0.46	-1.2%	1,968,947.57
	2012	0.4213	0.4243	0.7%	1,568,130.63
	2013	0.4187	0.4226	0.9%	1,513,429.95
	2014	0.4166	0.4201	0.8%	1,354,071.09

Table 7: Scenario B: Complexity Index and potential Financing Gain in Centro Hospitalar do Porto.

Two scenarios were analyzed regarding the possibility of substituting inpatient surgery for Ambulatory Surgery. This was accomplished with a patient centered focused anesthetic selection, and the utilization of specially designed perioperative protocols (short acting drugs, safe surgical conditions with deep neuromuscular block

and its monitoring, active control of residual paralysis by the use of unequivocal NMB reversal with sugammadex, and active PONV control). In both scenarios the potential impact is significant, both in terms of the number of avoidable inpatient days and in terms of the complexity indices.

In the scenario of the procedures classified with 'Yes', the impact in 2014 is -963 Ambulatory Surgery episodes performed comparing to the expected, which translates into at least 963 inpatient days over consumed, a potential increase of 2.3% in the Inpatient Complexity Index and 0.2% in the Ambulatory Surgery Complexity Index, which combined corresponds to a potential gain in financing of 2.74 Million Euros.

In the scenario of the procedures classified with 'Yes' or 'Maybe', the impact in 2014 is -2,044 Ambulatory Surgery episodes performed compared to the expected, which translates into at least 2,044 inpatient days over consumed, a potential increase of 5.1% in the Inpatient Complexity Index and 0.8% in the Ambulatory Surgery Complexity Index, which combined corresponds to a potential gain in financing of 5.94 Million Euros.

The reconfiguration of the hospital case-mix with the substitution of potentially ambulatory Inpatient episodes by Ambulatory Surgery leverages the complexity indices, both of the Inpatient and Ambulatory Surgery activity, with a direct translation to the hospital financing, and reduces inpatient days with an expected influence on costs associated to those episodes.

Conclusions

1. To safely ambulatorize inpatient surgical procedures, not only patient selection must be optimized, but also operating room routines and the choice of correct short acting drugs (propofol, remifentanyl, and rocuronium) and definitive NMB reversal policies (sugammadex) must be implemented. All these factors may induce more patient safety and satisfaction, and minimize the probability of the occurrence of an unsuccessful result.

2. It is worth to plan ambulatorize more complex surgical procedures because it increases the ambulatory and inpatient case-mix, with positive hospital revenue.

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