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Fast-track rehabilitation for lung cancer lobectomy: a five-year experience☆

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Abstract

Objective: Fast-track rehabilitation is a group of simple measures that reduces morbidity, postoperative complication and accelerates postoperative rehabilitation reducing hospital stay. It can be applied to lung cancer lobectomy. Fast-track rehabilitation cornerstones are: minimally invasive surgical techniques using video-assisted and muscle sparring incisions, normovolemia, normothermia, good oxygenation, euglicemia, no unnecessary antibiotics, epidural patient-controlled analgesia, systemic opiods-free analgesia, early ambulation and oral feeding. Our objective is to describe a five-year experience with fast-track rehabilitation for lung cancer lobectomy. **Patients and methods:** A retrospective non-controlled study including 109 consecutive patients submitted to fast-track rehabilitation in the postoperative care of lung cancer lobectomy was performed. Only collaborative patients who could receive double-lumen intubation, epidural catheters with patient-controlled analgesia, who had Karnofsky index of 100, previous normal feeding and ambulation, absence of morbid obesity, diabetes or asthma, were eligible. Postoperative oral feeding and aggressive ambulation started as soon as possible. **Results:** Immediate postoperative extubation even in the operation room was possible in 107 patients and oral feeding and ambulation were possible before the first hour in 101 patients. Six patients could not receive early oral feeding or ambulate due to hypnosis secondary to preoperative long effect benzodiazepines. Two patients could not ambulate immediately due to epidural catheter misplacement with important postoperative pain. Ninety-nine discharges occurred at the second postoperative day, four of them with a chest tube connected to a Heimlich valve due to air leak. No complication of early feeding and ambulation was observed. Postoperative hypnosis due to long duration benzodiazepines or pain does not allow early oral feeding or ambulation. Avoiding long duration preoperative benzodiazepines, immediate postoperative extubation, regional thoracic PCA and early oral feeding and ambulation were related to a lesser frequency of complication and a shorter hospital stay. **Conclusion:** Fast-track rehabilitation for lung cancer lobectomies can be safely performed in a selected group of patients if a motivated multidisciplinary group of professionals is available and seems to reduce postoperative complication and hospital stay.

Keywords: Fast-track rehabilitation; Enhanced recovery after surgery

1. Introduction

Fast-track (FT) postoperative rehabilitation is a group of simple measures that reduces morbidity and mortality and accelerates postoperative rehabilitation and hospital discharge [1].

1.1. FT preoperative measures

FT measures begin several days before the operation. It begins when the surgeon, allied to a multidisciplinary group of professionals [2] expose FT principles and begin a patient and family educational program [3].

Physical exercise program, dietary education and tobacco cessation begin some weeks preoperatively.

Unnecessary preoperative hospitalization or fasting is avoided. Patients and their families are oriented about the advantages of being hospitalized some minutes just before surgical procedure [4].

1.2. Intraoperative measures

First of all, long duration pre-anesthetic benzodiazepines are avoided in order to allow immediate postoperative extubation, early patient wake-up aiming at early oral feeding and ambulation.

Operating room is warmed and its temperature is adjusted for patient protection, aiming for normothermia [5].

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An epidural thoracic catheter is placed. It is used during all the operative act and is kept in place to be used postoperatively.

Hypervolemia, hypoglycemia and hypooxygenation is avoided. Anesthesiologists try to achieve a perioperative negative fluid input balance, normoglycemia and normoxygenation [6].

Minimally invasive techniques are applied, as are thoracic muscle sparring incisions and video-assistance [7,8], allied to rational use of drains and tubes [9].

Postoperative epidural patient-controlled analgesia is the cornerstone in order to achieve optimal pain relief; it is based on a free systemic opiods principle. PCA devices are installed before the patient leaves the operating room.

1.3. Postoperative measures

Immediate postoperative extubation is always performed when possible.

Urinary catheter is immediately taken out in the operating room at the end of the surgical procedure.

No unnecessary antibiotic is used and they are stopped immediately at the end of the operation [10].

Early ambulation and oral feeding associated with aggressive physiotherapy exercises begin some minutes after extubation, even in the operating room [11].

This group of simple measures allows early lung expansion, early chest tube withdrawal and avoids complications related to systemic opiods side effects, related to immobility and to unnecessary catheters, drugs, excessive intravenous fluid and fasting.

2. Objectives

Our main objective is to describe a five-year experience with fast-track surgery program implantation and its complications for lung cancer lobectomy in a thoracic surgery service of an oncological hospital.

Our secondary objective is to verify if avoiding long duration preoperative benzodiazepines, performing immediate postoperative extubation, early ambulation (within the 1st postoperative hour) early oral feeding (within the 1st postoperative hour) and thoracic regional patient-controlled analgesia are measures related to a lower frequency of complications and a lower hospital stay.

3. Patients and methods

3.1. Study design and institution where data were collected

It is a retrospective non-randomized non-controlled study involving a cohort of patients operated on for lung cancer based on the principles of fast-track postoperative rehabilitation.

It was performed in a tertiary level complex thoracic surgery service in a non-university oncological hospital.

3.2. Inclusion criteria

All the consecutive patients who received pulmonary lobectomy due to lung cancer who were able to walk and feed orally before operation, who were eligible for epidural thoracic analgesia and who had no exclusion criteria were included.

3.3. Exclusion criteria

Exclusion criteria were: patients who were not cooperative in the preoperative period, who had a Karnofsky index other than 100 or who had one of the following comorbidities: asthma, morbidity obesity, diabetes or who had any contraindication for epidural thoracic anesthesia. Patients with these comorbidities were routinely sent to our reference quaternary hospital (Sao Paulo University Medical School General Hospital).

Patients who did not receive fast-track care or those whose lobectomy was not due to lung cancer were not included in the study.

Patients who were lost to follow-up before the first postoperative year were excluded.

3.4. Casuistic

Medical charts review regarding pulmonary lobectomies due to lung cancer between 2000 and 2004 was performed.

3.5. Methods

3.5.1. Multidisciplinary training

Anesthesiologists, surgeons, nurses, physiotherapists, nutritionists and administrative staff were invited to take part in an educational program where FT principles were deeply debated and explained.

As it was an initial experience in our service, in order to avoid non-motivated personnel in the program, only voluntary paramedical professionals were trained to perform the FT procedures. They were also encouraged to propose solutions about how to adapt these measures to be implanted in our service routine, and also how these measures could be better and more easily performed.

3.5.2. Preoperative period

Since the first out-patient consultation, families and the patient received information about the role of perioperative physical exercises, tobacco cessation and a healthy dietary intake. Advantages of postoperative early ambulation and oral feeding were discussed too.

Physiotherapists also explained in the first out-patient consultation the importance of complementary physical exercises to optimize lung expansion. Physiotherapists afforded and explained how to properly use respiratory physiotherapeutic devices that the patients were going to use in the preoperative, intrahospital and postoperative period.

Patients and their families were instructed to perform physical aerobic exercises. We believe that familial support is the cornerstone for patient adherence to the program. Exercises must be performed if possible during the longest period of the day. Patients and their families were instructed

also about the advantage of having a dietary intake based on vegetables, fruits, legumes, fish, vegetable oils and grains.

An educational program was implanted to help patients and families stop smoking. Anti-tobacco therapy was indicated when necessary.

Always when possible these preoperative measures were kept during a minimal period of two weeks.

Detailed information was provided by the surgeon concerning anesthesia, incision, chest tubes. Surgeon finally reinforced the role of pre- and postoperative and intrahospital ambulation during the longest period possible, of feeding precociously at the immediate postoperative minutes, and reinforced the importance of physiotherapy exercises.

A direct telephone number for the surgical team was afforded to patient and family, to be used in case of additional information requirement.

Telephone calls were routinely made by the surgeon to the patient and family every three or four days during these two preoperative weeks in order to avoid any preoperative program failure and to give additional information.

3.5.3. Hospitalization

Hospitalization duration was analyzed in days as one of the studied variables.

Patients were hospitalized some minutes before operation. Glucose enriched crystalloid liquids could be orally taken until 6 h before hospitalization.

3.5.4. Anesthesia

Long duration benzodiazepines were avoided as a preoperative drug, because its hypnotic effect could make immediate postoperative oral feeding and ambulation difficult.

Surgical rooms were warmed to keep a 25 °C temperature in order to avoid hypothermia.

A thoracic epidural catheter was placed before general anesthesia, to be used during the intraoperative anesthesia and in the postoperative period in a patient-controlled analgesia device.

Left double-lumen intubation was performed.

Anesthesiologists aimed at an intraoperative negative intravenous solutions imbalance. Anesthetic drugs and measures should allow immediate extubation in the operating room as soon as possible, aiming at immediate patient wake-up in order to allow physiotherapy exercises, early oral feeding and ambulation.

3.5.5. Intraoperative measures

Despite video surgery being one of cornerstones of FT, in this service during the period surgeries were performed, VATS devices were not already completely implanted. Thus, all the lobectomies were performed through an open incision.

Posterior muscle sparring thoracotomy was performed in the auscultation triangle, with complete sparring of both *latissimus dorsi* and *anterior serratius* muscles always when possible. In 12 patients we needed to divide partially or completely the latissimus dorsi, and in seven of them it was completely divided because in medical charts it is described that anterior serratius was divided too. Regarding anterior serratius muscle and the remaining five latissimus dorsi division not followed by anterior opening, it was not possible to recovery data from medical charts regarding whether the muscle division was complete or partial.

Pleural drainage was achieved by the placement of two silicone 36 Fr chest tubes, one along the paravertebral region and another in a parasterenal position. They were previously completely multi-perforated, along all the chest tube extension from 2 cm from the internal pleural surface until the cranial extremity of the tube.

During the first year, chest tubes were inserted from the most possible inferior intercostal space and placed along all the extension of pleural cavity until the most cranial position, but avoiding contact to the apical pleura, in order to avoid apical pain. Since the second year, we have changed the chest tubes insertion position. They were inserted three intercostal spaces caudally from thoracotomy intercostal space to be located in a region under epidural anesthetic effect. It was changed due to the pain that some patients had at the chest tube insertion region when they were inserted at the lowest possible position.

Only during the first year, before closing chest wall incisions, block intercostal nerves anesthesia and local anesthesia around the chest tubes were performed using bupivacaine during the first year. From the second year until now it is performed no more.

A patient-controlled analgesia device was immediately connected to epidural catheter even in the surgical room. It used a small electric device that was completely mobile and battery charged, in order to allow easy immediate postoperative ambulation.

Fentanyl and bupivacaine were the preferred drugs in PCA during the first year, but ropivacaine replaced bupivacaine during the second year. Morphine was avoided due to intestinal constipation and urinary retention.

Patients with adverse effects of opiods received only local anesthetic drugs for PCA.

If thoracic epidural or paravertebral catheter placement was not possible, venous PCA would be used.

3.5.6. Extubation

Patients were immediately extubated in the operating room when possible.

Delay between the incision closure and extubation was recorded in minutes. If it was achieve in the surgical room before the 25th postoperative minute it was considered as 'immediate' extubation.

3.5.7. Catheters and venous lines withdrawal: the 'wireless' situation

In order to facilitate early ambulation, urinary catheters were immediately taken out and venous lines were kept in place without any continuous fluid. It was called the 'wireless' situation.

3.5.8. Early physical exercises

At the operative room, immediately following extubation, patients were accommodated in a seated position and started physiotherapy exercises, except ambulation, which was started at the ICU some minutes later.

Even during the transport from operating room to the ICU, patients performed physical exercises, as moving up the

upper extremities accompanied by deep inspiration with a 2 s inspiratory apnea, followed by moving down upper extremities accompanied by deep expiration.

3.5.9. Immediate ICU exercises

Patients were sent to ICU where there they were immediately stimulated to keep on moving the extremities, breathing deeply, coughing and to remain seated in the bed in a 5—50 min period.

3.5.10. Oral feeding

Delay between beginning extubation and oral feeding was recorded in minutes and was one of the studied variables.

Early oral feeding was also recorded as a dichotomous variable: it was considered achieved when patient started orally feeding before the first postoperative hour and not achieved when started later.

Prophylactic antiemetic intravenous drugs were administrated before feeding. Water drinking and feeding started at the same time within one or two postoperative hours.

3.5.11. Ambulation

Delay between extubation and first ambulation was recorded.

Early ambulation was also recorded as a dichotomous variable: it was considered achieved when patient started ambulation before the first postoperative hour and not achieved when started later.

If there was no complication, the patient was stimulated to stand up beside the bed and simulate ambulation without moving from the place in a 5—50 min period. Surgeon and anesthesiologist aided the patient in walking slowly in the ICU room during a 20—30 min period. Physiotherapeutic exercises started at once.

In a period of one or two hours, in the absence of complications, patients would be able to walk in the corridor outside the ICU, always accompanied by the surgeon.

3.5.12. Analgesia

Postoperative pain control was one of the studied variables.

Severe pain was considered as any pain level that denied early ambulation, and it was recorded as a postoperative complication as a dichotomous variable.

Analgesia consisted in systemic opiod free analgesia. It was based on orally given free opiods analgesic drugs associated with a thoracic epidural patient-controlled analgesia. In case of a not successful epidural catheter placement, an intraoperative paravertebral subpleural catheter was placed.

A small and easily transported electric device, based on rechargeable battery, was used to PCA. Anne Pump ABBOTT® was chosen.

3.5.13. Chest tubes withdrawal

At the 12th postoperative hour, the anterior chest tube was taken out if there was no air leak, bleeding, purulent drainage or more than 150 ml/12 h debit from this anterior tube.

In 24 h, if the posterior chest tube debit was less than 250 ml/24 h, it was taken out. If not, at the 48th postoperative hour, the posterior chest tube was taken out, despite the amount of drained liquid, except in case of bleeding or air leak

Walking, deep breathing and exercises were continued for three or four hours after chest tube was taken out.

Patients were discharged if no symptom or signal of pneumothorax, bleeding or other complications were detected after these three or four hours of aerobic exercises.

3.5.14. Discharge recommendations and on line support

As discharge recommendations, the surgeon reinforced the instructions for ambulation, aerobic exercises, physiotherapeutic maneuvers, maintenance of healthy diet and smoking cessation.

The patient should remain accompanied by an oriented and capable adult, who should have facilities to transport the patient, be able to drive and have a domiciliary telephone.

On-line support was afforded and consisted of direct telephone numbers for the surgeons and the hospital.

A telephone call was done by the surgeon to contact patient and family each two or three days.

Out-patient clinical and radiological follow-up at the 7th and 14th days were performed.

3.5.15. Late follow-up

Patients were followed-up until the first postoperative year in our department. After this period they were followed-up exclusively by the oncology department. The following late postoperative complications were studied: persistent air leak, pleural and wound chronic infection and chest wall dehiscence or hernia.

3.6. Analyzed variables

3.6.1. Intra- and postoperative complications

The following intraoperative complications were recorded as a dichotomous variable: cardiac arrest and bleeding.

The following were considered postoperative complications as well: hypnosis, epidural displacement, drain drop, air leak, bleeding, constipation after the first postoperative day under laxative diet, urinary paralysis, pruritus secondary to opiods allergy, cardiac arrhythmia and infection.

3.6.2. Hospital stay

It was recorded in days.

3.7. Ancillary analysis

Postoperative complication frequency and hospital stay averages were compared between patients for whom FT measures were achieved and those for whom any FT measure was not.

3.8. Statistics

Software: SPSS-10® (Chicago, IL, USA).

3.8.1. Descriptive statistics

Descriptive statistics was performed to describe casuistic, operative complications and hospital day. Frequencies described binary or categorical variables and average and

median described continuous parametric and non-parametric variables respectively.

3.8.2. Univariate analysis

Fisher's exact test was used to compare two frequencies. Kolmogorov—Smirnov test with Lilliefors significance correction was used to define if continuous variables distributions were parametric. Student's unpaired *t*-test would be used to compare means for approximately normally distributed data. Mann—Whitney test should be used to compare medians in case of non-parametric distribution. Statistical significance was considered when $p < 0.05$.

3.8.3. Multivariate analysis

Logistic regression was used to predict postoperative complications in function of FT measures achievement as independent variables.

4. Results

4.1. Casuistic

One hundred and twenty-one consecutive pulmonary lobectomies due to lung cancer were performed between 2000 and 2004.

There were no patients with severe asthma, morbidity obesity, severe diabetes or who had any contraindication for epidural thoracic anesthesia, because they were normally sent to our referred quaternary hospital.

Eight patients who had lung cancer and who were treated by pulmonary lobectomy were not included because they could not normally walk preoperatively. Two patients were not included because they were not cooperative in the preoperative out-patient consultation and did not agree to receive perioperative care based on FT surgery.

One patient was excluded because her definitive postoperative diagnosis was abscess. Another was excluded because of the lack of follow-up data since the second postoperative week.

Medical charts of 109 consecutive patients who had inclusion criteria and were followed for a period longer than 12 months were analyzed. Longer follow-up was not considered because our objective was to study only operative complications.

There were 32 (29.4%) female and 77 (70.6%) male patients.

The average of age was 63.45 years, with a 95% confidence interval for mean ranging from 62.12 to 64.78 years and a standard deviation of 6.99 years; values ranged from 45 to 81 years.

4.2. Fast-track measures achievement

There was no difference between the age average of patients who achieved (99 patients) and those who do not achieve (8 patients): Student's unpaired *t*-test ($p = 0.859$). However 5/26 females against 3/73 males did not achieve FT measures ($p = 0.044$; Fisher's exact test).

4.2.1. Hypnosis due to preoperative long duration benzodiazepines

FT measures were applied for 102 patients who could orally feed and ambulate precociously (93.6%), but it was not possible for seven patients (6.4%), because of hypnosis secondary to the preoperative use of long duration benzodiazepines.

4.2.2. Regional thoracic analgesia

In 102 patients, thoracic epidural anesthesia was achieved, but in 7 cases catheter placement was not possible due to anatomic features. In five of them, a paravertebral intrapleural catheter was placed intraoperatively. Two patients had intravenous morphine based PCA.

Techniques and drugs used in postoperative analgesia are displayed in Table 1.

4.2.3. Immediate postoperative extubation

Immediate postoperative extubation was possible in 107 patients (98.2%), but not in two (1.8%), both of them due to intraoperative cardiac arrest.

4.2.4. Immediate postoperative ambulation

Immediate postoperative ambulation was possible in 99 patients (90.4%), but not in 10 (9.6%): 2 of them were already described as having an intraoperative cardiac arrest, 6 of them because of hypnosis as a side effect of preoperative long duration benzodiazepines and 2 of them due to severe pain secondary to epidural catheter displacement.

4.2.5. Early oral feeding

Despite 1 h being considered as a cut-off for early oral feeding, 101 patients were awake enough to receive oral feeding before the 40th postoperative minute, but eight of them were not, two patients because they were intubated due to intraoperative cardiac arrest, and six patients because of hypnosis secondary to preoperative long duration benzodiazepines.

Although five of them were completely awake, they did not accept feeding orally because they were afraid of vomiting.

4.2.6. Vomiting prophylaxis

Twenty-eight patients (25.7%) vomited when woken up after extubation, but all of them could feed orally within 60 min.

Two of them received systemic opiods as postoperative analgesia due to thoracic epidural catheter displacement;

Table 1
Frequency of techniques and drugs used in postoperative analgesia.

Postoperative analgesia	Frequency	Percent
Only local anesthetic in thoracic epidural PCA	2	1.8
Fentanyl and local anesthetic in thoracic epidural PCA	74	67.9
Fentanyl and local anesthetic in paravertebral subpleural PCA	5	4.6
Morphine and local anesthetic in thoracic PCA	21	19.3
Systemic opiods in venous PCA	3	2.8
Intubated patients	4	3.6
Total	109	100.0

Table 2
Frequency of intra- or postoperative complication.

Type of complication	Frequency	Percent
No complication	71	65.1
Intraoperative cardiac arrest	2	1.8
Hypnosis due to preoperative long duration benzodiazepines	6	5.5
Thoracic epidural catheter displacement	2	1.8
Accidental chest tube displacement	1	0.9
Persistent air leak	4	3.7
Minor intraoperative bleeding	4	3.7
Constipation during opiods use	9	8.3
Urinary retention during opiods use	4	3.7
Concomitant constipation and urinary retention during opiods use	3	2.7
Postoperative cardiac arrhythmia	1	0.9
Pruritus during opiods use	2	1.8
Total	109	100.0

eight patients received morphine as a PCA thoracic epidural analgesia and five of them had a paravertebral subpleural catheter.

Vomiting was not computed as a postoperative complication because it did not interfere with oral feeding before the 1st postoperative hour or with early ambulation.

4.3. Intra- and postoperative complications

They are displayed in Table 2. Vomiting was not considered as a complication as discussed before. There was no case of operative infection, pleural infection occurred in two patients with chronic air leak, but occurred only some weeks after hospital discharge.

4.4. Hospital stay

Hospital stay values are normally distributed data (Kolmogorov–Smirnov test with Lilliefors significance correction, $p = 0.001$). The discharge postoperative day frequency is displayed in Table 3.

The median hospital stay was two days. The minimal hospital stay was one day for one patient and the maximal 31 days for a patient who had intraoperative cardiac arrest with neurological damage.

Table 3
Hospital stay: the postoperative day of discharge.

Postoperative day of discharge	Frequency	Percent
1st	1	0.9
2nd	98	89.9
4th	3	2.8
5th	4	3.7
6th	1	0.9
10th	1	0.9
31st	1	0.9
Total	109	100.0

4.4.1. Fast-track measures and hospital stay

Table 5 shows the comparison of hospital stay median (in days) in function with fast-track measures achieved or not (without two unconscious patients).

4.4.2. Comparison of postoperative complications frequency and hospital stay

Postoperative complications were more frequent (Table 4) and hospital stay average longer (Table 5) in the group of patients where fast-track measures were not completely achieved. Two patients, who suffered intraoperative cardiac arrest and remained intubated for several days and could not refer pain, pruritus, be orally fed, walk, or they suffered a urinary obstruction because they remained with a urinary catheter, were therefore not included in this analysis.

4.5. Multivariate analysis

Logistic regression identified only ambulation as a predictive (protective) independent variable of postoperative complication among the following candidates: preoperative long duration benzodiazepines, immediate extubation, early oral feeding and severe pain, as shown in Table 6.

Table 4
Comparison of postoperative complication frequency in function of fast-track measure achieved or not (without two unconscious patients).

FT measure	FT measure achieved or not	PO complication frequency (%)		p^*
		Without	With	
Avoided long duration preoperative BDZ	Achieved	77 (76)	24 (24)	0.0001
	Not achieved	0 (0)	6 (100)	
Immediate extubation	Achieved	77 (72)	30 (28)	***
	Not achieved	0 (0)	0 (100)	
Early ambulation (within the 1st PO h)	Achieved	77 (78)	22 (22)	0.0001
	Not achieved	0 (0)	8 (100)	
Early oral feeding (within the 1st PO h)	Achieved	77(76)	24 (24)	0.0001
	Not achieved	0 (0)	6 (100)	
Thoracic regional PCA**	Achieved	77 (73)	28 (27)	0.077
	Not achieved	0 (0)	2 (100)	

FT: fast-track; BDZ: benzodiazepines; PO: postoperative; h: hour.
* Level of statistic significance of Fisher's exact test (2-sided).
** Epidural or paravertebral subpleural catheter.
*** Extubation was achieved in all these 107 patients.

Table 5
Comparison of hospital stay in function of fast-track measure achieved or not (without two unconscious patients).

FT measure	FT measure achieved or not	*n*	Mean ranking	Sum of ranks	*p* *
Avoided long duration preoperative BDZ	Achieved	101	52.6	5313	0.0001
	Not achieved	6	77.5	465	
Immediate extubation	Achieved	107	54	5778	***
	Not achieved	0	0	0	
Early ambulation (within the 1st PO h)	Achieved	99	51.6	5104	0.0001
	Not achieved	8	84.3	674	
Early oral feeding (within the 1st PO h)	Achieved	101	52.6	5313	0.0001
	Not achieved	6	77.5	465	
Thoracic regional PCA**	Achieved	105	53	5569	0.0001
	Not achieved	2	104.5	209	

FT: fast-track; BDZ: benzodiazepines; PO: postoperative; h: hour.
* Level of statistic significance Mann—Whitney test (two-tailed).
** Epidural or paravertebral subpleural catheter.
*** Extubation was achieved in all these 107 patients.

Table 6
Logistic regression identifies early postoperative ambulation as a predictive variable of postoperative complication.

		B	S.E.	Wald	df	Sig.	Exp(*B*)	95.0% CI for EXP(*B*)	
								Lower	Upper
Step 1	Ambulation	3.450	1.081	10.177	1	0.001	31.500	3.782	262.327
	Constant	−1.253	0.242	26.854	1	0.000	0.286		

A variable(s) entered on step 1: ambulation; S.E. standard error; df: degrees of freedom; Sig.: significance; CI: confidence interval; EXP *B*: neperian exponential of *B*.

4.6. Ancillary analysis

4.6.1. Severe pain and hospital stay

Eight patients had severe pain. Two of them had their thoracic epidural catheter displaced in the perioperative period.

Hospital stay median in the group of eight patients who suffered severe pain was higher than the group of patients without severe pain ($p = 0.049$, two-tailed Mann—Whitney test).

4.6.2. Severe pain and complications

There was no difference in the frequency of studied complications between the group of patients with and without severe pain (Fisher's exact test, $p = 0.40$). They occurred in 27 of 99 patients without severe pain (excluding two of them who were unconscious) and in 3 of 8 patients with pain.

4.7. Post-discharge complication rates and readmission rates

There were seven (6.4%) cases of patients who had small atelectasis due to pain at the first postoperative week outpatient consultation. Among them, 2 (1.8%) had a small pleural effusion that disappeared within the first postoperative month.

One patient claimed that after a Valsalva maneuver in the first postoperative week, she could notice some clear fluid flowing through the posterior chest tube orifice. Always when she coughed or repeated this maneuver, the flow increased. Curiously, at the CRX there was neither pleural effusion nor pneumothorax. The flow stopped when the orifice was closed by the natural scar.

Two patients with small but persistent alveolar air leak were discharged with a Heimlich valve connected to the 36 Fr chest tube placed after surgery and evolved to pleural empyema.

One patient was readmitted in the second postoperative week due to an ischemic stroke not related to FT.

5. Discussion

5.1. Limitations of this study

First of all this is a not controlled study, so we cannot conclude that any of these FT measures could reduce postoperative complications or hospitalization in comparison to traditional postoperative care.

Second of all it is a biased population due to our service level of complexity. Thus, we cannot conclude that these FT measures could be safely applied to a more complex population, with more comorbidities or more extensive tumors.

5.2. Fast-track surgery implantation

Tradition plays an important role in perioperative care, but many routine procedures are not based on evidence. Medical and paramedical professionals tend to keep doing routine procedures as they have learned during their academic and professional lives.

It was realized that FT could be implanted only after its principles were explained to all the medical and paramedical professionals involved in the patient perioperative care, and after they understood its principles and were in fact

convinced of FT benefits [12]. We also realized that patient and family information and close contact with surgeons and physiotherapists facilitated collaboration and FT feasibility [13].

Another important factor we believe facilitates FT is that it started at least two weeks before the surgical operation, allowing patients to became used to exercises, physiotherapy devices, healthy dietary intake and smoking cessation.

5.3. Postoperative complications

Some postoperative complications can be considered as secondary to traditional measures adopted routinely in perioperative care.

Although it was not a controlled study, we realized that patients who could not feed or walk had a higher frequency of complications and a longer hospitalization [14,15].

We believe that rational use of drugs and intravenous crystalloid fluids, catheters, fasting and bed immobilization can reduces morbidity in lung cancer lobectomy.

Univariate analysis identified differences between frequencies of complications and hospital stay comparing patients for whom one of these specific FT measure was achieved to another for whom this specific measure could not be achieved.

Multivariate analysis identified only early ambulation as a predictive variable of postoperative complication. This series of cases with a biased population where complications were less frequent is small because our casuistic was recruited in a tertiary hospital. Selection is routinely done in this situation because patients with comorbidities were sent to the reference quaternary hospital. Multivariate analysis will identify other predictive variables if a non-selected population is studied where a predicted event (postoperative complication) is more frequent and not biased.

5.3.1. 'In time' hospitalization

We believe early hospitalization is not necessary if the patient is well informed about perioperative care, but troubles due to 'in time' hospitalization can occur if there is any delay in coming to the hospital. In our casuistic one patient had to be operated later in the same day and another two days later.

We also believe that 'in time' hospitalization could, perhaps, favor a domiciliary bacteria flora and a less psychologically stressed patient.

5.3.2. Focused FT anesthesia

It was realized that anesthesiologists play a crucial role in FT. It is imperative that chosen drugs, the anesthetic techniques, intravenous fluid imbalance and the immediate extubation lead to early oral feeding and ambulation.

5.3.3. Systemic drugs

We realized that the anesthesiology team involvement is one of the cornerstones of FT. At the beginning of FT implementation in our hospital there were some cases when anesthesiologists gave patients preoperative long duration benzodiazepines or postoperative systemic opiods. Hypnosis, besides pain, is the worst enemy of FT.

5.3.4. Thoracic catheter for patient-controlled epidural analgesia

An epidural thoracic catheter was placed before the operative procedure. There are groups who place the catheter in the immediate postoperative period. We prefer that patients wake up with the patient-controlled analgesia device [16].

In our series, patients for whom epidural catheter could not be placed or suffered displacement could not follow the FT program because they had severe pain or hypnosis due systemic opiods.

5.3.5. Thoracic epidural PCA pump

'Wireless' patient mobility requires small pumps connected to batteries with durable autonomy. FT does not work well if non-mobile, voluminous and hard pumps are used. We utilize a light easily transportable PCA pump (Anne Pump, ABBOTT®) with a shoulder strap that can be placed as a shoulder bag.

When pumps without shoulder straps were used, patients had to push their pumps in a mobile support, but we realized that these pump models discouraged patients ambulating.

5.3.5.1. Antibiotics. Antibiotics may be used rationally [10]. In this series, there was no wound infection or pneumonia during hospitalization in patients for whom early oral feeding and ambulation was achieved.

5.3.5.2. Intravenous crystalloid fluids. We realized that if venous lines were kept connected to any fluid, there was a tendency of ICU personnel to keep the fluid infusion. So, we decided to keep the venous lines, but without any fluid connected to them. Thus, the ICU personnel did not tend to keep these lines without any unnecessary infusion [17].

5.3.5.3. Urinary catheters. We had realized that in some cases they were kept in place even some hours after patients did not need them anymore, more than being an unnecessary measure, catheters made for difficult patient ambulation.

5.3.5.4. Immobilization. We had realized that patients rested in the ICU bed for several hours and sometimes even for one or two days. Unnecessary immobilization can lead to paralytic ileus and atelectasis. Furthermore, paralytic ileus makes oral feeding difficult resulting in additional postoperative morbidity [18].

Chest tube aspirators and battery feed devices, when indicated, must be mobile, in order not to make ambulation difficult.

5.3.5.5. Postoperative fasting. Postoperative fasting also was considered as an unnecessary measure for aware patients [19]. Even when vomiting at the first drinking water intake, patients could feed normally some minutes later.

5.3.5.6. Early oral feeding. Dietary education for FT may begin two weeks before surgical procedure; patient and family must be informed about the crucial importance of healthy feeding in the perioperative period. Family is requested to bring any special meals that are better accepted by the patient and that are not routinely prepared in the hospital.

Nutritionists are involved in the FT care, offering adequate meals to the patient and encouraging them to feed.

We believe that this group of simple measures can be adopted even in tertiary hospitals in routine perioperative care and seems to reduce surgical morbidity.

6. Conclusion

1. Fast-track surgery for lung cancer can be implanted and safely performed if a multidisciplinary approach and a prepared team is available. Patient family involvement plays an important role.
2. Avoiding long duration preoperative benzodiazepines, performing immediate extubation, thoracic regional patient-controlled analgesia, early ambulation and oral feeding all seem to be related to a lower frequency of complications and a lower hospital stay.

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Appendix A. Conference discussion

Dr G. Varela (*Salamanca, Spain*): I have a couple of questions. First, I have seen in your pictures a three-ball incentive spirometer. That is a flow-based spirometer. Is that the device you are currently using or was it just a picture for illustration?

Dr Das-Neves-Pereira: It was just a picture. We used a device called the respiron.

Dr Varela: Without 3 balls?

Dr Das-Neves-Pereira: Yes. It is the blue one where you do like this and the little ball goes up (indicating).

Dr Varela: So it's a volume-based incentive spirometer, isn't it?

Dr Das-Neves-Pereira: Yes.

Dr Varela: The second thing is, what exactly is the interest of discharging a patient the second day after lung resection?

Dr Das-Neves-Pereira: When we started this program, this hospital was a very special hospital. There was a garden around it. It was a one-floor hospital. When the patients started to walk in the corridor, we realized that the lung could expand very well. So what happened, we started it around the fifth day, but as the years were passing, we realized that they (patients) were orally feeding, with oral medication, the analgesia, and we started to ask ourselves, why stay at the hospital? So some of them went home. So our aim was not to discharge the patients. It was just a consequence because they had an expanded lung and could walk and orally feed. In fact, nowadays I ask myself if some of them had any kind of arrhythmia, cardiac arrhythmia, but when they came back in one week, at the seventh postoperative day, the majority were okay.

Dr Varela: So you would see all your patients 7 days after lung resection in your outpatient clinic?

Dr Das-Neves-Pereira: Yes. They had to come back at the seventh day, all of them. If they couldn't, if they didn't have anybody home who could bring them to the hospital, they were referred to our quaternary hospital.

Dr Varela: And you were shifting your expenses from the ward to the outpatient clinic?

Dr Das-Neves-Pereira: In fact, what happened, when we started this program some of the administrative staff were interested in this program because they were worried about costs. They said we have low costs because the patients are discharged. We were not worried about costs. What we were aiming was to reduce morbidity. If it's cheaper, I don't mind about this, but, in fact, they said it can lower the costs.

Dr J. Groetzner (*Muenster, Germany*): I have just a short question. Maybe you can give me a short comment on the way you selected the patients. Maybe I missed it.

Dr Das-Neves-Pereira: It's a biased population. We had a wide selection of patients. When the services referred a patient to us, if they referred, for example, patients with cardiac disease, we sent the patient to the quaternary hospital of the University of Sao Paulo. For us it's a biased population. They were already selected. When we realized that they had any cardiac trouble, for example, or asthma or diabetes that was difficult to control, we sent them to the quaternary hospital.

Dr T. Gudbjartsson (*Reykjavik, Iceland*): You said discharged home. Were these patients discharged to another institution or to a patient hotel? What is the definition of 'home'?

My second question is, were there any readmissions? Were the patients coming back in after they were discharged home?

Dr Das-Neves-Pereira: This is one very interesting aspect, because before this study the patients were in the hospital for 5 days. Some of them came back to the hospital and we consulted literature about complications. We were afraid of discharging them. But they came back to the hospital with some doubts about pain or asking to change the oral medication. There were no grave complications. We didn't have any patients with great vessel bleeding or so on.

Dr S. Elia (*Rome, Italy*): I have some technical questions just to make sure that everybody understands.

First of all, you said this is a retrospective study, but in your abstract you said it's a prospective, noncontrolled study, so you should better explain what your inclusion criteria were, if you have a set of patients that you went back on the records and then you selected upon some certain characteristics or you decided to have these patients rehabilitated in a fast way.

Secondly, I have seen that you have an impressively low incidence of air leaks, only 4. Did you use any kind of supplementary protection, like glue, or whatever for fissures or for the bronchial stump to avoid these air leaks? Another thing, did you put aspiration on these patients after the operation?

Dr Das-Neves-Pereira: The second question about the protection of the bronchus, we didn't use glue. In this hospital we didn't have that during this period. What we used was a pleural patch without muscles and covered the bronchus, but without glue.

Dr Elia: In all patients?

Dr Das-Neves-Pereira: No patients. During that period in this hospital, we didn't have glue.

The other question?

Dr Elia: Did you put the patients on aspiration?

Dr Das-Neves-Pereira: No. Some years before, we used the aspiration, but as we did not have the mobile device, drains were branched to the vacuum from the wall, so we realized they could not walk in the corridor, so we started to.

Dr Elia: No. If you decide to send the patient home, there is no need to have a mobile device. I mean you put them under aspiration, then you have to check if there is an air leak or not, and then you can send them home. This is not the question. I'm saying did you routinely put the patient on aspiration after the procedure or not?

Dr Das-Neves-Pereira: No.

Dr S. Halezeroglu (*Istanbul, Turkey*): How did you do the pain management if you removed the epidural catheter 2 days after the operation?

Dr Das-Neves-Pereira: The first patients stayed more than 2 days because we wanted to use the epidural anesthesia. Even if they were walking or feeding, we believed that we should let them use the PCA at the hospital. Perhaps they are in bed and we asked, 'Do you have pain?' and they do, but what we realized is that when they start walking, the intensity of pain decreased. I don't know why the level of pain decreased. For this reason, we didn't need to use the PCA for more than 3 days or 4 days.