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Elena Carrese *

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Research Article

The Outcome of Lung Cancer Surgery in Patients on Chronic Hemodialysis: A Multicenter Study

Elena Carrese [1]*, Cristian Rapicetta [1], Alessandro Stefani [2], Tommaso Ricchetti [1], Alberto Matricardi [1], Daniel Bianchi [1], Pier Luigi Filosso [2], Massimiliano Paci [1]

[1]Unit of Thoracic Surgery, Azienda USL- IRCCS di Reggio Emilia.

[2]Unit of Thoracic Surgery, Azienda Policlinico-Universitaria di Modena.

***Corresponding Author:** Elena Carrese, Thoracic Surgery Unit, Azienda USL-IRCCS di Reggio Emilia, viale Risorgimento, 80 – 42100. Reggio Emilia – Italy.

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Abstract

Background/Aim: The end-stage renal disease is arising worldwide and their prognosis and quality of life of these patients have improved due to advances in dialysis techniques and improvement in clinical management. The incidence of tumors are increased but there are few reports about pulmonary resection in hemodialysis patients with lung cancer.

Methods: The study included 19 hemodialysis patients undergoing curative surgery for lung cancer in 3 centers in 20 years considering pre-operative, perioperative variables and their relationship with morbidity, mortality and survival.

Results: The complication rate was 84%, with a mortality rate of 5%. The most common complication was bleeding. Heavier smoking history was associated to higher risk of developing complications. The 5-years overall survival (OS) rate was 29%, while the 5-years Disease free survival (DFS) rate was 62%. OS was correlated with age and clinical stage. Most patients showed non cancer-related deaths.

Conclusion: The mortality is remarkable in hemodialysis patients, but the data about OS and DFS make us believe that lung surgery may be still a therapeutic option in selected patients and with careful perioperative management.

Key Words: hemodialysis, lung cancer, end-stage renal disease, pulmonary resection

Abbreviations:

OS (5-years overall survival); **DFS** (5-years Disease free survival); **FEV1** (Forced Expiratory Volume in 1 second); **DLCO** (Diffusing capacity of the lungs for carbon monoxide); **FE** (Ejection Fraction); **CCI** (Charlson Comorbidity Index); **ECOG** (Eastern Cooperative Oncology Group); **COPD** (Chronic Obstructuve Pulmonary Disease); **CPK** (creatinphosphokinase values); **SEER** (Surveillance, Epidemiology and End Results del National Cancer Institute).

Introduction

The number of end-stage renal disease patients on hemodialysis is on the rise worldwide. The prognosis of these patients has improved due to advances in dialysis techniques leading to decrease in incidence of death for cardiovascular disease. Conversely the incidence of infection and malignant disease is increasing instead [12]. The relative risk of lung cancer, unlike other types of cancer, does not seem to be higher than normal population [22], but as the prevalence of patient on hemodialysis increases, the number of surgery resections for lung cancer is expected to increase.

The management of systemic therapy for lung cancer is very complex in patient receveing hemodialysis and there is little data avaible about target therapy and immunotherapy [23]. Patients on dialysis represent a high risk group beacause of cardiovascular disease, diabete mellitus, electrolyte imbalance, hemodynamic instability, metabolic disorder, anemia, bleeding tendency, immunosoppression. These problems can lead to post-operative complication, requiring careful peri-operative management [12]. However, there are only few reports about pulmonary resection in hemodialysis patients with lung cancer.

Materials and Methods

This is a multicenter retrospective observational study who involves hemodialysis patients undergoing pulmonary resection for lung cancer in the last 20 years (2000-2021) in 3 different Thoracic Surgery Centers. Patients undergoing peritoneal dialysis and who have started dialysis in perioperative period were excluded.

The variables collected were:

- Preoperative: gender, age, smoking habit, performance status, body mass index, FEV1 (Forced Expiratory Volume in 1 second), DLCO (diffusing capacity of the lungs for carbon monoxide), PaO2, PaCO2, cardiac Ejection Fraction (EF), Charlson Comorbidity Index (CCI), taking antiplatelet/anticoagulant drugs, type of nephropaty, duration of hemodialysis, serum urea, creatinine, potassium, hematocrit, hemoglobin, total proteins (the values are referred to the day before the operation), time elapsed between the last hemodialysis session and the operation.
- Intraoperative: type of surgical access (Thoracoscopy ot thoracotomy), type of intervention, type of limphadenectomy, duration of the intervention, intraoperative bleeding.
- Postoperative: serum potassium value, time interval between operation and the first hemodialysis session, need for urgent dialysis sessions, postoprative complications (typology of complications and severity according to Clavien-Dindo classification), need for blood transfusions, admission to intensive care, duration of drainage, length of post-operative hospital stay.
- Related to the neoplasm: clinical stage, pathological stage, hystotype.
- Follow-up: patient status (alive/dead), presence of recurrence, site of recurrence, cause of death, overall survival and cancer related survival and disease free survival at 1,2,3,4,5.
- Times: dialysis start date, date of surgery, date of last observation, recurrence date, death date.

Classifications used are:

- ECOG (Eastern Cooperative Oncology Group) Performance status;
- Charlson Comorbity Index;
- Clavien-Dindo Classification of complications.

Performance statuts is an evalution of patient’s general conditions and daily life skills. ECOG scale, published by Oken et al. nel 1982 [1], allows to assign a score from 0 to 5, where 0 indicates perfect health while 5 indicats death.

Charlson Comorbity Index (CCI) is used to classify comorbidities that affect mortality risk [2]. 19 medical conditios are considered (16 diseases, 3 of which are stratified according to gravity); each is given a score from 1 to 6, with final score from 0 to 33. Score is adjusted with age, getting a combined age comorbity index from 0 to 37.

Clavien-Dindo Classification is a complication subdivision system [3].

Statistical analysis

Descriptive Statistics: categorical variables were expressed as frequencies and percentages. Continuous variables were expressed by mean +/- standard deviation or median and interquartil range.

Analytical Statistics: preoperative and intraoperative variables were analysed with complications to identify possible associations. Comparison between categorical variables was performed with Chi square test (Fischer exact-test correction was used for small samples as indicated); continuous variables were compared with Student’s T-Test or ANOVA. The variables arranged in ranks were compared with non-parametric tests (Mann-Whitney or Kruskal-Wallis). As cut-off for the categorization of continuous variables in 2 subgroups median value of variable was used.

Survival was considered from intervention to last observation date (OS) or from intervention to recurrence date (DFS), if present. The OS and DFS were computed by the Kaplan-Meier method, and differences between groups calculated using the Log-Rank test.

Some statistical tests, given the small sample size, had not been carried out because of low reliability. All statistical analyses were performed using SPSS 26.0 (SPSS inc., Chicago, IL).

Limitations.

The limitations of this work are: retrospective study and small sample size. Furthermore, the data collection is spread over twenty years, therefore it isn’t considered progress in recent years about surgical techiques with the introduction of new technoligies, improvements in dialysis technique and in chronic management of dialisys patient resulting in increased survival.

ETHICAL APPROVAL

This study was approved by Ethics Committee of Azienda USL-IRCCS of Reggio Emilia (207/2021/OSS/IRCCSRE on 27/4/2021).

Results

Characteristics of the patients

Patients's characteristics are shown in the Table 1.

Variables	N
Gender - Male - Female	 15 (79%) 4 (21%)
Age (years) - Average - Range	 71 51-84
Smoking habit (p/y) - Average - Range	32,5 7-90
Performance Status (ECOG)	

0 1 2	8 (42%) 8 (42%) 3 (16%)
BMI (kg/m2) - Average -Range	 25 20 - 33
Respiratory function - average (range) - FEV1 (L/s) % - DLCO (mL/min/mmHg) % - PaO_2 (mmHg) - $PaCO_2$ (mmHg)	 89 (44-146) 76 (53-101) 89 (68-116) 40 (32,5-56)
Cardiac ejection fraction - Average - Range	54 40-60
Charlson Comorbidity Index - 0-5 - 6-10 - 11-15	 1 (5%) 17 (90%) 1 (5%)
Antiplatelets/Anticoagulants - Yes - No	 11 (58%) 8 (42%)
Nephropaty - Glomerulonephritis - Nephroangiosclerosis - Diabetic nephropaty - Interstitial nephropaty - Polycystic kidney disease	 6 (31,5%) 7 (37%) 2 (10,5%) 2 (10,5%) 2 (10,5%)
Duration of hemodialysis (months) - Average - Range	 27 2 – 62
Preoperative biohumoral tests Average (range) - Urea (mg/dL) - Creatinine (mg/dL) - Potassium (mmol/L) - Hemoglobin (g/dL) - Serum proteins (g/dL)	 89 (17-145) 6,7 (3,8 - 11,5) 4,7 (3 - 6,3) 12,2 (9,2-14,7) 8 (4,5-8,3)

Table 1. Preoperative variables

The study includes 19 patients, mostly men (15/19, 79%), with an average age of 71 years. All subjects were smokers or former smokers. Nephroangiosclerosis and Glomerulonephritis were the main causes of end-stage renal failure (37% and 32% respectively). The average duration of dialysis was 27 months. The last dialysis for surgery was performed the day before surgery in all but 2 patients. Regarding respiratory function, the values of FEV1% were <80% in 3 patients (16%), PaO_2<80 mmHg in 3 cases (16%). All patients had an echocardiogram with cardiac ejection fraction values <50% in 4 cases (21%). Regarding biohumoral tests, urea and creatinine were obviously high on average, while potassium value and serum proteins were well controlled. Most patients presented preoperative anemia (68%). Eleven patients (58%) were taking antiplatelets drugs (8/10), including acetylsalicylic acid, clopidogrel and ticlopidine, or warfarin and enoxaparin as anticoagulants (2/10). For one patient it is unknown whether he took antiplatelets or anticoagulants.

Charlson Comorbidity Index has a maximum of 37 points, but in this study the maximum score was 13. Most patients had a score between 6-10. Most common comorbidities were arterial hypertension (13 cases), chronic peripheral vascular disease, chronic ischemic heart disease, presence of other malignant neoplasm and COPD (Chronic Obstructuve Pulmonary Disease) (*Table 2*).

Comorbidities	**N (%)**
Arterial Hypertension	13 (68)
Chronic Vascuolopathy	6 (31)
Chronic ischemic heart disease	6 (31)
Neoplasm	5 (26)
COPD	4 (21)

Epatopathy HCV-related	2 (10,5)
Insulin-dependent Diabetes	2 (10,5)
Atrial Fibrillation	2 (10,5)
Stroke oucomes	1 (5,2)
Chronic Respiratory Failure	1 (5,2)
Cardiac valvulopathy	1 (5,2)
Epilepsy	1 (5,2)

Table 2: Comorbidities

Perioperative Variables

The *Tables 3 and 4* summarize variables related surgery and postoperative period. In 16 patients surgical access was thoracotomy, while only 3 patients underwent videothoracoscopy; lobectomy was performed in most patients (68%) and in all cases the intervention was radical.

Variables	N
Type of intervention - Lobectomy - Wedge resection	 13 (68%) 6 (32%)
Type of linfoadenectomy - Sampling - Radical - None	 14 (74%) 2 (10%) 3 (16%)
Duration of intervention (min) - Average - Range	 144 (67-260)
Intraoperative blood loss (mL) - Average - Range	 266 (0-2000)

Table 3: Intraoperative Variables

Complication	N (%)
Hemorrhage	5 (26)
Hyperkalemia	4 (21)
Pneumonia/lung abscess	3 (16)
Respiratory failure	3 (16)
Prolonged air loss	2 (10,5)
Acute Respiratory Distress Syndrome (ARDS)	1 (5)
Atelecyasis/Bronchial obstruction	1 (5)
Heart Failure	1 (5)
Acute Myocardial Infarction	1 (5)
Pulmonary Edema	1 (5)
Intestinal Perforation	1 (5)

Table 4: List of postoperative complications

Variables	N
Postop Potassium (mmol/L) - Average - Range	 4,2 3,2-8,4
Emergency dialysis - Yes - No	 6 (32%) 13 (68%)
Postoperative complications - Yes	 16 (84%)

- No	3 (16%)
Clavien – Dindo Classifications - I - II - III -IV - V	 4 (21%) 5 (26%) 2 (10,5%) 6 (32%) 2 (10,5%)
Blood transfusion - Yes - No	 9 (47%) 10 (53%)
Intensive care admission - Yes - No	 9 (47%) 10 (53%)
Duration of drainage (days) - Average - Range	 8 2-69
Post-operative hospital stay (days) - Average - Range	 17 (6-54)

Table 5: Post-operative Variables

The results about complications were: sixteen patients (84%) presented postoperative complications (included hyperkalemia), ranked according Clavien-Dindo Classification. The *Table 4* shows the list of complications. 10 patients presented only one complication, 3 patients 2 complications and 3 patients 3 complications.

Transfusion was necessary in 9 patients for hemoglobin value <8 g/dL and admission in Intensive care in 9 patients (7 patients of which for respiratory or multiple organs failure). The use of blood transfusion was necessary in 47% of cases and 68% of patients had a drop in preoperative hemoglobin values. The association between the two events was statisticallly significant. Emergency dialysis was performed in 6 patients, in 5 for hyperkalemia and in 1 case for acute pulmonary edema. In the last cases the first postoperative dialysis was performed in 10 cases on the first post-operative day and in 5 cases two days after surgery. 30-day mortality was 5%, because one patient died after 27 days. If we consider in-hospital mortality, the percentage rises to 10,5%, because one patient died 37 days after surgery. The cause of death was multiple organ failure in both cases. They both had a CCI of 9 and had undergone lobectomy and wedge resection repectively.

Variables related to tumor and survival

Histologically, the most common tumor was adenocarcinoma (*Table 6*), according to the increased incidence in the whole population. Most of patients were in stage I (15/19, 79%), as represented in the *Table 7*.

Histological type	***N (%)***
Adenocarcinoma	*12 (63)*
Squamous cell carcinoma	*6 (32)*
Other	*1 (5)*

Table 6: Variables related to hystological type

Stage	***N (%)***
Ia	*10 (53)*
Ib	*5 (26)*
IIa	*0 (0)*
IIb	*2 (11)*
IIIa	*2 (11)*

Table 7: Stage-related Variables

The average follow-up was 34 months. At the end of follow up 14 patients died (74%), including the 2 post-operative deaths: 3 patients died of cancer, while 11 patients died of other causes. 4 patients relapsed (21%), 3 loco-regional recurrences and 1 cerebral recurrence. 2 of these patients died after 29 and 38 months, one patient died 11 months later, while one patient was alive after 63 months, with a recurrence within 8 months. Median overall survival was 4 months. The OS and DFS are showed in *Figure 1* and *2*.

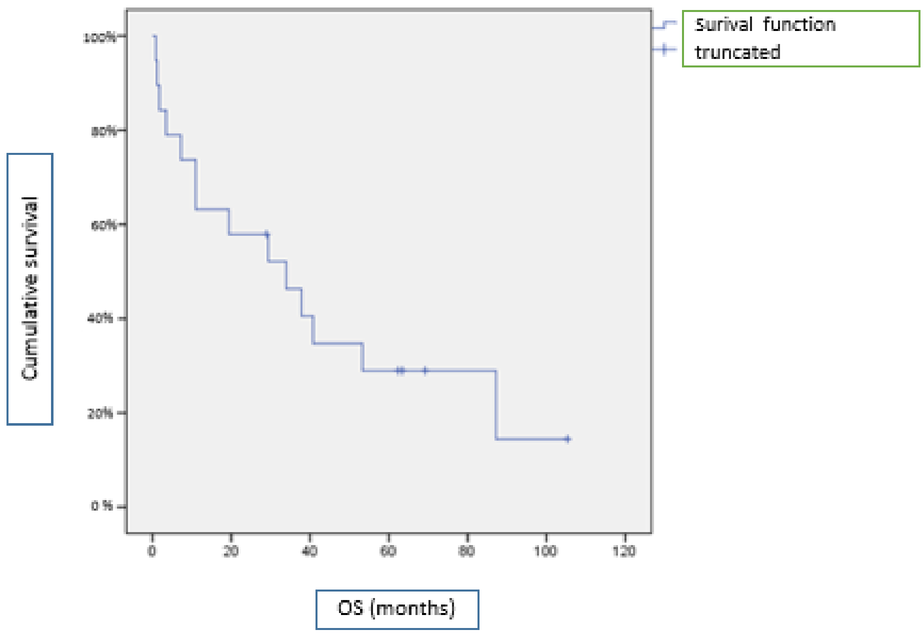

Figure 1: The Kaplan-Meier survival curve represents the Overall survival. OS at 1, 3 and 5 years is 63%, 46% and 29% respectively.

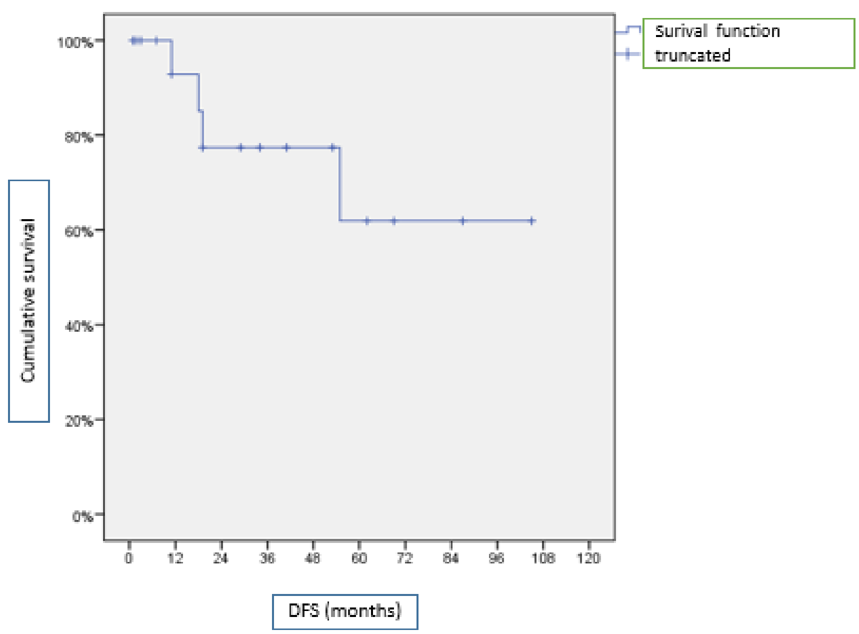

Figure 2: The Kaplan-Meier survival curve represents the Disease-free survival. DFS at 1, 3 and 5 years is 93%, 77% and 62% respectively.

Regarding the preoperative and perioperative factors affecting the development of complications, the only statistically significant association involved the smoking habit. Patients with an important story of cigarette use had a higher incidence of complications (*Table 8*).

	complications	N	Average	Std. Deviation	P value
pack/years	no	6	19,50	6,595	0,033
	si	12	39,00	19,684	

Table 8: Significant correlation between smoke and complications (T-test average comparison, p=0.033).

No association was found between complications and age, ECOG, respiratory function, EF, CCI, levels of creatinine/potassium in the blood. Preoperative dialysis duration did not affect complications, but influenced the lenght of hospital stay according to an inverse correlation (*Table 9*).

	Grouped lenght of stay	N	Average	Std. Deviation
Dialysis duration (months)	<=11	10	36,90	20,798
	>11	9	13,33	12,104

Table 9: Significant correlation between dialysis duration and lenght of hospital stay (T-test average comparison, p=0.009).

Conversely the lenght of hospital stay was not affected by CCI.

Regarding blood complications, the analysis found an association between preoperative hemoglobin and need for transfusion *(Table 10)*.

	Postop transfusion	N	Average	Std. Deviation
Preoperative Hemoglobin	no	11	12,773	1,2133
	si	8	11,388	1,4904

Table 10: Significant correlation between preoperaive hemoglobin and Postoperative transfusion (T-test average comparison, p=0.039).

We also found a statistical significant association between transfusion and complications *(Table 11)*.

			Complications		Total
			no	yes	
Postop Transfusion	no	Count	6	5	11
		% postop transfusion	54,5%	45,5%	100,0%
		% complications	100,0%	38,5%	57,9%
		% of the total	31,6%	26,3%	57,9%
	yes	Count	0	8	8
		% postop transfusion	0,0%	100,0%	100,0%
		% complications	0,0%	61,5%	42,1%
		% of the total	0,0%	42,1%	42,1%
Total		Count	6	13	19
		% postop transfusion	31,6%	68,4%	100,0%
		% complications	100,0%	100,0%	100,0%
		% of the total	31,6%	68,4%	100,0%

Table 11: Significant correlation between transfusion and complications (T-test average comparison, p=0.012).

Regarding mortality, no statistical significant association was founded with variables under study.

The type of surgery did not influence complications *(Table 12)*, or survival *(Figure 3)*.

			Complications		Total
			no	yes	
Type of surgery	lobectomy	Count	4	9	13
		% type of surgery	30,8%	69,2%	100,0%
		% complications	66,7%	69,2%	68,4%
		% of the total	21,1%	47,4%	68,4%
	wedge	Count	2	4	6
		% type of surgery	33,3%	66,7%	100,0%
		% complications	33,3%	30,8%	31,6%
		% of the total	10,5%	21,1%	31,6%
Total		Count	6	13	19
		% type of surgery	31,6%	68,4%	100,0%
		% complications	100,0%	100,0%	100,0%
		% of the total	31,6%	68,4%	100,0%

Table 12: correlation not significant between type of surgery and complications (T-test average comparison, p=0.911).

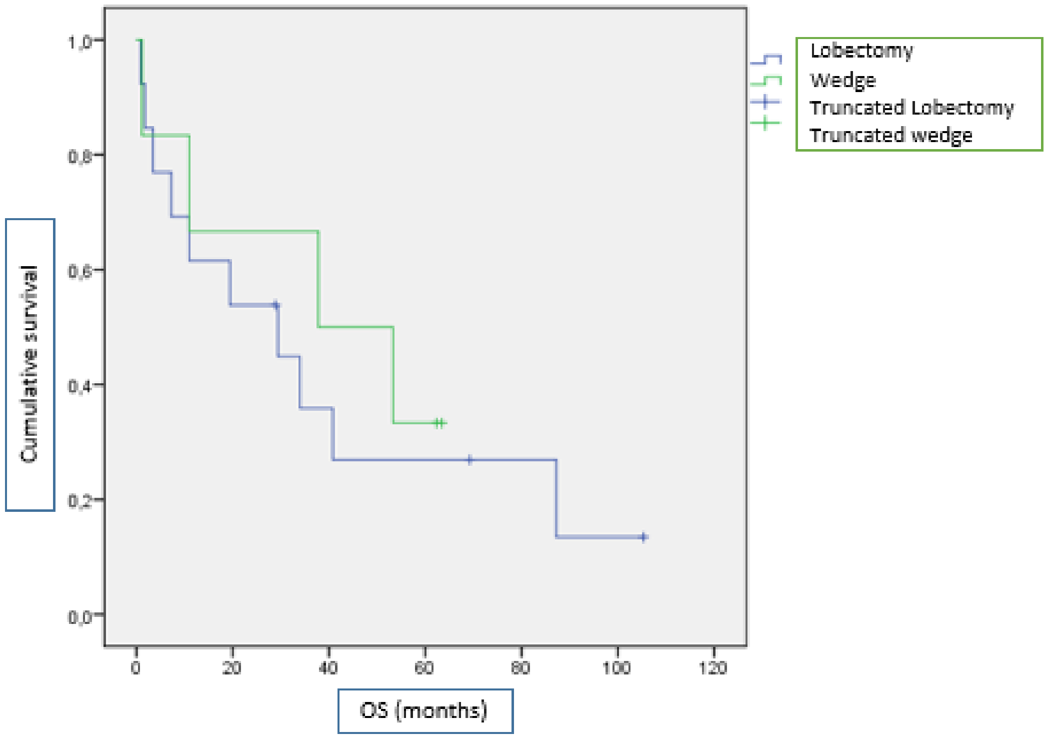

Figure 3: Survival curve in relation to type of surgery.

The analysis of survival curves highlited that survival is unfavorably affected by advanced age and stage *(Figure 4-5).* The relation between ECOG and complications are at the limits of statistical significance *(p value 0,061 and 0,063 respectively).* No significant associations were found between survival, sex, repiratory function, levels of creatinine and potassium in the blood, dialysis duration and CCI.

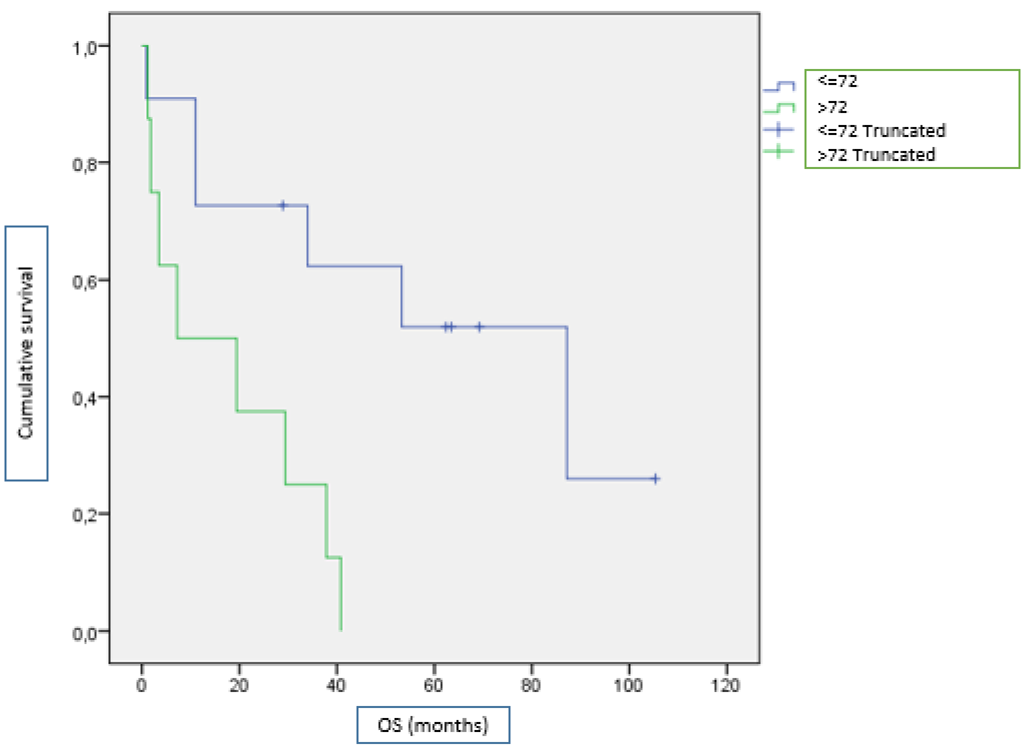

Figure 4: The survival curves highligth a significantly better survival in young patients, (≤72 years old vs >72 years old), with 73% Vs 0% 5-yrs survival rates respectively and a Median Survival of 87 and 7 months respectively (p<0,08).

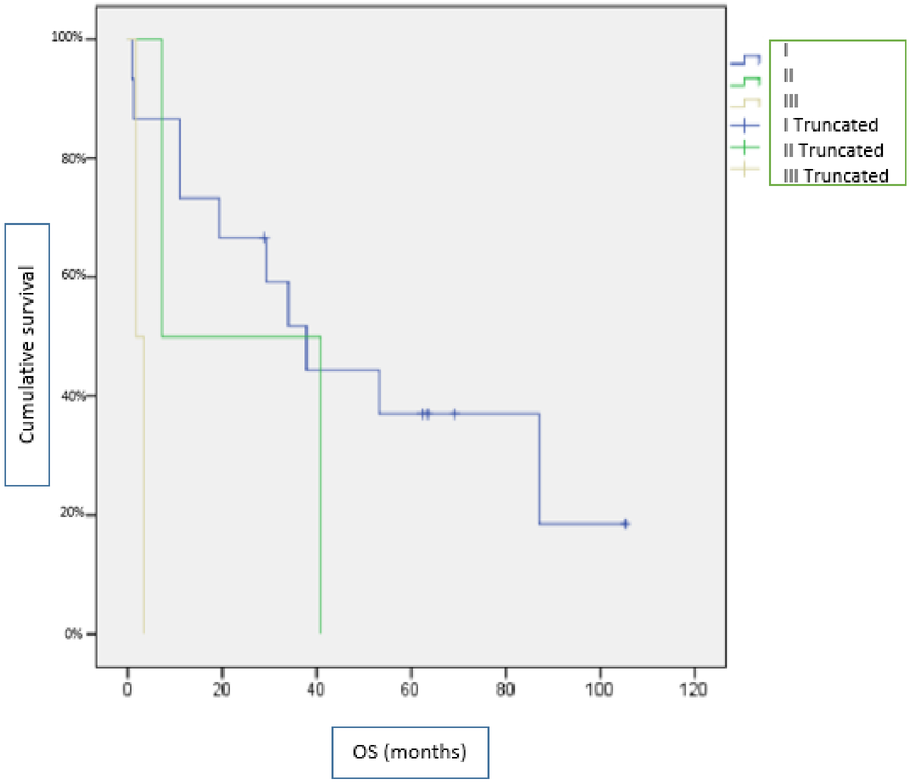

Figure 5: The survival curves highligth a significantly better survival in early stage (p<0,019).

Discussion

The present work is a multicenter retrospective observational study that focuses on the outcomes of lung surgery for cancer performed on hemodialysis patients.

Postoperative complication rate was 84%, 26% of which for hemmorhage and 21% iperkalemia. Regarding complications in other studies, these vary from 27% to 100%. A deitailed analysis shows that complications most frequently in other studiese are: pnemonia [4,6,7,10,11,12,14,15], atrial fibrillation [4,5,8,12,13], iperkalemia [4,5,11,14] and bronchial obstruction [4,5,8,11].

The association between blood transfusion and preoperative hemoglobin values was statisticallly significant, thus implying the need for careful monitoring of hemoglobin values and eventually the preoperative use of erythropoiesis stimulating agents or iron, according to international guidelines. Furthermore, having found the association between transfusion and risk of complications, it would be amenable to reduce the use of this practice.

Many studies have recorded the frequent use of nafamostat mesilato (drug used in Japan) as anticoagulant during dialysis [4,10,11,13,14]. In contrast to heparin, it prolongs clotting time only in extracorporeal circuit; it is used in Japan in patients at high risk of bleeding. In contrast, Tomizawa e Watanabe [11,13], considering the absence of bleeding with the use of heparin, they believe that this drug can be used safely. According to data reported by Ciriaco [5], the bleeding risk is minimized by reducing the heparin dosage. In Tsuchida's study [4] the use of antiplatelets an anticoagulants drugs did not affected bleeding.

Perioperative management involves careful monitoring hydroelectrolyte balance. In this regard, many authors consider it is useful monitoring with central venous catheter and an arterial catheter [4,6]. Ciriaco [5] demonstrated that preoperative dialisys performed two consecutive days before surgery and the day after surgery reduced the extent of hydrolytic imbalances. According to the date reported by Watanabe [13], in our study 89% of patients (17/19) performed the last dialysis session the day before surgery. First hemodialysis session was performed in 10 cases on day after surgery and in 5 cases two days after surgery. Emergency dialysis was necessary in 6 patients, in 5 patients due to excessively high level of potassium and in one case due to acute pulmonary edema.

Morita [16] reported association between postoperative potassium level and the increase in creatinphosphokinase values (CPK) and the extension of muscle resection. Since video thoracoscopy requires less muscle resection than thoracotomy, it is believed that this may be advantageous in reducing potassium levels [8,10]. Obuchi [7] compared population undergoing thoracotomy vs videothoracoscopy: no statistically significant differences were found in this study regarding duration of surgery, bleeding, duration of drainage and length of hospital stay. In our case stady, such comparison was not possible due to the small number of patients undergoing minimally invasive surgery.

In this study the risk of complications was associate to smoke. Both the incidence of complications and hospital stay were significantly higher than the general population (average 17 days, median 11 days). Hospitalization was associated to duration of preoperative dialysis according to an inverse correlation. This probably is due to the fact that hemodialysis patients for longer period have already achieved a good balance therefore they don't have need of more days of hospitalization. From the analysis of the literature, the association between smoke and complications is confirmed by Watanabe [13], who also identifies an association with the duration of surgery. Yamamoto [12] identifies as a risk factor for complications large lung resections and hystory of stroke. In this study we don't found association between type of surgery and complications. Furthermore in our case sudy there is only one patient with history of ictus, died after surgery; he had severe vasculopaty and arterial hypertension. Other authors note a greater risk of complications subjects with cardiovascular comorbidities or reduced respiratory function [6,14]. Tomizawa [11] identifies an association between complications and CCI; also he highlights the risk of exacerbation of interstitial pulmonary disease is greater in dialysis patients than general population (50% vs 9,3%) [17].

Table 13 shows the results of the studies, in the last twenty years, about hemodialysis patients undergoing to surgery for lung cancer, excluded case reports. From data present in the literature, it is note that postoperative mortality rate varies from 0 to 14%, therefore, our date (5%) is placed in the first half of the distribution. In-hospital mortality was remarkable (10,5%), but not higher than that previously reported in other studies. Postoperative mortality in hemodialysis patients is higher than general population: 6% for pneumonectomy, 3% for lobectomy and less than 1% for wedge resections [18].

Authors	Publication's year	Number of patients	Number of patients with Stage Ia (%)	Morbility %	Mortality %	OS 5 years %
Morita et al.	2001[16]	5	1 (20)	60	0	ND
Tsuchida et al.	2001[4]	7	1 (14)	100	14	ND
Ciriaco et al.	2005[5]	6	3 (50)	57	0	50
Obuchi et al.	2009[15]	11	6 (55)	27	0	28
Takahama et al.	2010 [6]	24	10 (42)	59	0	43
Obuchi et al.	2011[7]	14	8 (57)	29	0	40
Suehiro et al.	2011[14]	21	ND	76	0	ND
Matsuoka et al.	2013[8]	5	1 (20)	40	0	60
Park et al.	2015[9]	7	2 (29)	43	14	34
Otsuki et al.	2018[10]	7	4 (50)	43	0	25
Tomizawa et al.	2019[11]	21	8 (38)	67	5	26
Yamamoto et al.	2020[12]	39	27 (69)	31	8	58
Watanabe et al.	2020 [13]	38	ND	49	0	ND
Carrese et al.	2025	19	10 (53)	84	5	29

Table 13: Study results on hemodialysis patients undergoing resection for lung cancer.

As for long term results, OS at 3 and 5 years was respectively 46% and 29%. In other studies [4-16] 5 years OS varies from 25% to 60%, therefore our data is in the average of that reported in literature.

According to data from SEER (Surveillance, Epidemiology and End Results del National Cancer Institute), 5 years OS for lung cancer is 26,7%. Considering survival by stage, 5 years OS is 63,7% for early-stage, 35,9% for involvement of regional lymph node; 8,9% for metastatic tumors; 15,6% for unstaged forms [19]. Therefore if we consider that patient scheduled for sugery have early-stage tumors, OS of 29% is lower than OS of general population (59,8%). However in our study there were also some stage III patients which may have worsened overall survival. Furthermore, it must be considered mortality due to causes other than cancer which is also high in other studies. *Table 14* reports, for each published study, the number of deaths from causes other than cancer: the total number of deaths was 79, of which 63% were non cancer-related, witnessing the impact of chronic renal failure and comorbidities on survival. Indeed, according to Japanese's report of Society of Dialysis Therapy, survival of dialysis patients is 61% at 5 years, 37% at 10 years and 23% at 15 years [21]; while, according to date of Italian society of nephrology, annual mortality is 17% [20].

Authors	Publication's year	Number of patients	N° of deaths	N° deaths by tumor	N° deaths by other causes	% N° deaths by other causes
Morita et al.	2001[16]	5	3	0	3	100
Tsuchida et al.	2001[4]	7	5	3	2	40
Ciriaco et al.	2005[5]	6	1	0	1	100
Obuchi et al.	2009[15]	11	6	2	4	67
Takahama et al.	2010 [6]	24	8	6	2	25
Obuchi et al.	2011[7]	14	7	3	4	57
Suehiro et al.	2011[14]	21	ND	ND	ND	ND
Matsuoka et al.	2013[8]	5	2	1	1	50
Park et al.	2015[9]	7	4	3	1	25
Otsuki et al.	2018[10]	7	3	2	1	33
Tomizawa et al.	2019[11]	21	9	3	6	67
Yamamoto et al.	2020[12]	39	17	3	14	82
Watanabe et al.	2020 [13]	38	ND	ND	ND	ND
Carrese et al.	2025	19	14	3	11	58
Total			79	29	50	59

Table 14: Causes of death in hemodialysis patients undergoing lung surgery for cancer.

Therefore, while the data on OS seem disappointing, the data on DFS are more comforting. Out of 14 dead patients, only 4 showed disease recurrence and 3 dead from cancer. DFS is definitely higher: 77% at 3 years 62% at 5 years. Also Yamamoto [17] reports similar data on DFS: 66,5% for stage Ia and 52,9% for other stages at 5 years.

In this study, the analysis of survival curves highlighted that survival is adversely affected by advanced age and stage. These associations have been extensively studied in literature, so it is not surprising that in our analysis resulted significant. The survival was not affected by type of surgery instead, this leading to reflection that major resections should not be denied in properly selected patients (young and with early-stage disease). An

interesting fact is that during of dialysis does not influence survival or complications.

Conclusions

Despite the limitations considered, a significant fact is certainly the association between smoke and complications, therefore smokers are considered at risk. Furthermore, results regarding bleeding indicate to pay attention to the management of these aspects, both preoperatively and postoperatively.

The results of the present study, in particular those about OS and DFS, demonstrates that surgery for lung cancer is a reliable therapeutic option in patients with end-stage chronic renal failure: accurate patients selection and careful perioperative management are mandatory to minimize complications since most of patients die from non cancer-related events.

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