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Does myasthenia gravis influence overall survival and cumulative incidence of recurrence in thymoma patients? A Retrospective clinicopathological multicentre analysis on 797 patients / Filosso, P.L., Evangelista, A., Ruffini, E., Rendina, E.A., Margaritora, S., Novellis, P., Rena, O., Casadio, C., Andreetti, C., Guerrera, F., Lausi, P.O., Diso, D., Mussi, A., Venuta, F., Oliaro, A., Lucchi, M.. - In: LUNG CANCER. - ISSN 0169-5002. - 88:3(2015), pp. 338-343. [10.1016/j.lungcan.2015.03.007]

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17/11/2026 16:10

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Does myasthenia gravis influence overall survival and cumulative incidence of recurrence in thymoma patients? A Retrospective clinicopathological multicentre analysis on 797 patients

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Highlights

- Thymoma is a rare mediastinal neoplasm with an estimated incidence of 3.2/1,000,000 people.
- The association between thymoma and paraneoplastic autoimmune disorders is well-known.
- Myasthenia Gravis (MG) is the commonest autoimmune disease in thymoma.
- Few papers evaluated the real MG clinical impact in thymoma patients.
- Aim of this paper is to evaluate whether MG may influence overall survival and recurrence development in thymoma patients.

Abstract

Objective

Aim of this study is to evaluate whether Myasthenia Gravis (MG) might influence Overall Survival (OS) and Cumulative Incidence of Recurrence (CIR) in thymoma patients.

Methods

this is a multicenter retrospective study of patients operated in 6 high-volume Italian Institutions between 1990 and 2012. OS was estimated by the Kaplan-Meier method and CIR by considering death from any cause as a competing event. Crude and adjusted comparisons by MG for OS and CIR were performed using Cox and Fine&Gray models. Adjusted models included MG, age, gender, stage, histology, induction therapy, completeness of resection, adjuvant therapy.

Results

Seven hundred ninety-seven patients were included: 375 (47%) had MG. MG patients were younger and more frequently female, with a B2-B3 thymoma. At the end of the study, 129 patients (54 with MG) developed a recurrence and 165 (66 with MG) died. At univariate analysis, MG showed a slight protective effect on OS, not confirmed by the multivariate model. Age, incomplete resection, advanced stages and thymic carcinoma were negative prognostic variables. Univariate analyses showed no evidence of MG protective effect on CIR. Advanced stages and induction therapy were significant negative predictors.

Conclusion

our study showed that MG was significantly associated with female, lower age and B2-B3 thymoma; it demonstrated a slight protective effect on OS at the univariate analysis which was not confirmed in multivariate as well as no impact on CIR. Advanced tumor stages and thymic carcinoma histology for OS and induction therapy and advanced stages for CIR were negative prognostic variables.

Keywords

- Thymoma;
- Surgery;
- Myasthenia Gravis;
- Paraneoplastic syndrome;
- Survival;
- Recurrence

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1. Introduction

Thymic Epithelial Tumors (TETs) are rare mediastinal neoplasms with an estimated incidence of 2.5-3.2/1,000,000 people. Thymoma, Thymic Carcinoma and Thymic Neuroendocrine Tumor are the three most important histological subgroups.

Thymoma is well known for several interesting features, including the association with autoimmune disorders, of which Myasthenia Gravis (MG) is by far the most common. Epidemiological data demonstrate that 10%–20% of myasthenic patients have a thymoma, whereas up to 30% of patients with thymoma have MG [1] and [2]. Moreover, 10%π15% of thymoma patients have paraneoplastic syndromes other than MG, and 4%π7% of myasthenic thymoma patients have more than one paraneoplastic disorder[3].

The thymus plays a central role in the immune system, because it is the central organ of T-cell development and maturation from bone marrow progenitors. One of the histological thymoma characteristics is the coexistence of a large number of lymphocytes CD4+ CD8+ double positive; this suggests that thymoma neoplastic epithelial cells retain function to induce T-cell development

as the normal thymic epithelium. Additionally, the autoimmune regulator system (AIRE) is essential for the autoreactivity screening [4]: T-lymphocytes with potential autoaggressive characteristics are deleted into the normal thymus medulla. In a normal working condition, only self-tolerant and immunosurveillant against neoplastic cells T-lymphocytes are systematically released from the thymus. Most thymomas present a thymopoietic activity: auto-reactive T-lymphocytes are exported from the neoplastic thymus, and can persist for long time in the periphery, explaining the possible onset of autoimmune disorders.
The MG clinical implication in thymoma has been investigated by several authors in the past [5], [6] and [7], but very few are the papers which compare differences in clinical characteristics and prognosis of thymoma patients with or without MG.
While in the 1970s MG management was problematic and its presence was an indicator of poor prognosis [8], the progress in preoperative neurological care, postoperative medical and respiratory support for MG patients caused an important improvement in survival, to the point that recent reports indicate that thymoma with MG have a better outcome compared to those without it [9].
It is however controversial whether the improved prognosis for MG thymomatous patients is due to an earlier thymoma detection, by a careful MG surveillance, or by the intrinsic biological tumor behavior.

Aim of this study is to evaluate whether MG may influence Overall Survival (OS) and Cumulative Incidence of Recurrence (CIR) in a large cohort of patients operated in 6 high-volume Italian Thoracic Surgery Institutions.

2. Material and methods

Between January 1990 and December 2012, 797 patients with TET were operated at 6 different Italian Institutions of General Thoracic Surgery.

Preoperative standard workup was similar in all the Centres and included: routine blood tests, electrocardiography (EKG), echocardiography if required (in case of invasive lesions, or high risk patients), pulmonary function tests with diffusion capacity and arterial blood gas analysis, total body computed tomography (CT) and magnetic resonance, when necessary (in case of invasive lesions). 18FDG-PET scan was not routinely performed.
All patients included in this study presented MG clinical symptoms. MG was diagnosed by each Centre's dedicated Neurologist team based on clinical criteria: fluctuating ocular, skeletal weakness that worsened with repeated efforts, and improved with rest or by injection of anticholinesterase drugs. MG was always confirmed by a decremental response to repetitive nerve stimulation and, sometimes, by high serum AchR antibodies titers.

Through a strict cooperation between Surgeons, dedicated Neurologists and Anesthetists to achieve the best preoperative clinical MG stabilization, no patient was operated during a myasthenic crisis, but with an acceptable clinical compensation, only.

Complete sternotomy was the standard surgical approach; lateral thoracotomy or combined incisions have seldom been performed, according to the tumor clinical/radiological presentation.

Following the International Thymic Malignancy Interest Group (ITMIG) standard outcome measures for thymic malignancies [10], surgery was considered radical if a complete tumor resection (R0) was achieved and, contrariwise, in case of micro-macroscopic residuals (R1-R2), incomplete.
Histology was assessed according to the 2004 World Health Organization (WHO) classification [11]; patients operated on or before 2004 were reclassified at each Centre using that classification. In accordance with ITMIG standards, tumor staging was determined using the Masaoka-Koga (MK) classification system [12]. Primary Neuroendocrine Thymic tumors were excluded from this study.
Follow-up protocol was quite similar in all the involved Centres: it included CT scan every 6 months for the first 3 years, and afterward on a yearly basis or on clinical demand.

Patients' clinical characteristics were obtained from hospital records; outcome data were acquired by outpatient visits or telephone interviews.

3. Statistical analysis

Continuous data are presented as median (interquartile range, IQR) and categorical ones as number (percentage, %).

Primary outcomes were Overall Survival (OS) and Cumulative Incidence of Recurrence (CIR).

OS was calculated from the date of intervention to the date of death from any cause. Patients alive were censored on the date of the last follow-up.

CIR was assessed from the date of surgery to the date of recurrence; patients alive or without any recurrence were censored on the date of the last follow-up. CIR was evaluated in case of R0 resection and when complete data concerning recurrence status were available, only.

Adjusted models including the following clinical variables were performed: MG (yes vs no), age at surgery (as continuous), gender (female as reference), MK stage (I/II as reference), tumor histology, preoperative therapy (no vs yes), completeness of resection (R0 vs R1-R2), adjuvant therapy (no vs yes) and decade of intervention (2000–2012 vs 1990–1999).

OS was estimated by the Kaplan-Meier method; CIR was estimated using the method proposed by Gooley et al. [13], considering death from any cause as a competing event. Crude and adjusted comparisons by MG for OS and CIR were performed using Cox and Fine&Gray models, respectively. Outcome heterogeneity by Centres was accounted by applying the model extensions (shared frailty) for clustered data analysis.
Additional comparisons according to the MG presence were performed on all patients and by histological subgroups, using the propensity score (PS) test. In order to adjust this comparison and to reduce the loss of power in the subgroup analyses, a PS for the likelihood of having MG was calculated from the following covariates: age, gender, resection status, histology, MK stage, preoperative therapy, adjuvant therapy. Regression models were estimated including as predictor the MG variable along with the PS. Effect modifications by histology were evaluated by including in the models an interaction term between the covariate indicating MG status and diagnosis, adjusting for PS.

All statistical analyses were performed using STATA (version 12.1) and R (version 2.15.1).

4. Results

Seven hundred ninety-seven patients (409 male, 51%; median age 58 years) with TETs were retrospectively included in this study: Table 1 summarizes their clinical characteristics.

Table 1.
Patients' clinical characteristics and outcomes.

Characteristics	TETa	TET without MG°	TET with MG	P
	(N = 797)	(N = 422)	(N = 375)	
Age (median, IQR)	58(48;69)			
Gender				P = 0.020
Female	388 (49%)	189 (45%)	199 (53%)	
Male	409 (51%)	233 (55%)	176 (47%)	
Completeness of resection				P = 0.219
R0	718 (90%)	375 (89%)	343 (91%)	
R1/R2	79 (10%)	47 (11%)	32 (9%)	
Masaoka-Koga Stage				P = 0.040°

Characteristics	TETa	TET without MG°	TET with MG	P
I	144 (18%)	68 (16%)	76 (20%)	
II	352 (44%)	180 (43%)	172 (46%)	
III	223 (28%)	127 (30%)	96 (26%)	
IV	78 (10%)	47 (11%)	31 (8%)	
Tumor Histology				P < 0.001
A-AB-B1	454 (57%)	248 (59%)	206 (55%)	
B2-B3	291(37%)	134 (32%)	157 (42%)	
Thymic Carcinoma	52 (6%)	40 (9%)	12 (3%)	
Adjuvant therapy				P = 0.454
No	159 (38%)	159 (38%)	151 (40%)	
Yes	263 (62%)	263 (62%)	224 (60%)	
Induction therapy				P = 0.033
No	674 (85%)	346 (82%)	328 (87%)	
Yes	123 (15%)	76 (18%)	47 (13%)	
Outcomes				
5-Year Overall Survival (95%CI)		84.9% (80.6–88.3)	93.6% (90.3–95.8)	
10-Year Overall Survival (95%CI)		70.9% (65.2–75.8)	77.2% (71–82.3)	
5-Year CIR (95%CI)		11.1% (7.6–14.6)	10.7% (7.2–14.3)	
10-Year CIR (95%CI)		15.7% (11.4–20)	14.7% (10.3–19)	

a
Thymic Epithelial Tumor.

°
Myasthenia Gravis ^Cumulative Incidence of Recurrence.

4.1. MG rate in TETs

4.1.1. MG was observed in 375 patients (47%).

Other paraneoplastic syndromes were seen in 52 patients (6%); the commonest were: thyroiditis (10 cases), rheumatoid arthritis [13], Pure Red Cell Aplasia [4], hypogammaglobulynemia [3] Sjogren's syndrome [3], neurological diseases [4]. Six patients presented the association of 2 paraneoplastic syndromes, and 1 three.

4.2. Clinical findings of TETs with and without MG

Patients with and without MG clinical characteristics are listed in Table 1.
MG patients were more frequently female (P = .02) and younger (P < .001) than non-MG ones. B2-B3 Thymomas were commonly observed in MG patients (P < .001); 12 patients with Thymic Carcinoma (23%) presented MG. Prevalence of MG by Center and time period (decade) are illustrated in Supplementary Table 1.
Masaoka-Koga clinical stage and treatment of TETs with and without MG

A trend towards a higher proportion of early MK stages in MG patients was observed. Patients without MG more frequently (P = .03) received preoperative treatment, due to their advanced stage. Contrariwise, adjuvant therapy was quite similarly offered to both groups of patients. R0 rates were also similar in the 2 groups.

4.3. Survival and recurrence of TETs with and without MG

Median follow-up was 87 months (IQR: 44–122 months); 718 patients (90%) have data available for CIR analysis.

At the end of follow-up 129 patients (54 with MG) developed a recurrence, and 165 (66 with MG) died.

Crude 5- and 10-year survival rates were 93.6% and 77.2% for MG patients and 84.9% and 70.9% for non-MG ones, respectively (Fig. 1). To eliminate possible influence of tumor stages on OS we also drew curves of patients with and without MG in stages III and IV: no significant differences were evident between the 2 groups (Fig. E1).

Fig. 1.
OS for patients with and without MG.

At univariate analysis MG showed a slight protective effect on OS (HR:0.74;95%CI:0.54-1.01, P = .058), which was not confirmed at the multivariate model (adjusted HR:0.99;95%CI:0.71-1.38, P = .956). Age, R1-R2 resection, Stage III-IV tumor and Thymic Carcinoma histology demonstrated to be negative prognostic variables (Table 2).

Table 2.
Overall Survival. Cox proportional hazard model with shared frailty (N = 797)a.

Crude	HR(95%CI)	p
MG	0.74 (0.54 to 1.01)	0.058
Adjusted		
MG	0.99 (0.71 to 1.38)	0.956
Age (continuous)	1.05 (1.04 to 1.07)	<0.001
Male	1.29 (0.94 to 1.78)	0.11
Incomplete Resection (R1/R2)	1.62 (1.02 to 2.57)	0.04
Masaoka Stage		
I (Ref)	1	–
II	1.92 (1 to 3.67)	0.049
III	4.09 (1.98 to 8.46)	<0.001
IV	10.45 (4.75 to 23)	<0.001

Crude	HR(95%CI)	p
Diagnosis		
Thymoma WHO A-AB-B1 (Ref)	1	–
Thymoma WHO B2-B3	1.38 (0.95 to 2)	0.087
Thymic carcinoma	2.42 (1.47 to 3.99)	<0.001
Adjuvant Therapy	0.63 (0.42 to 0.95)	0.027
Induction Therapy	0.88 (0.58 to 1.34)	0.564
Year Intervention 2000–2012 vs 1990–1999	0.75 (0.53 to 1.05)	0.092

a

[Variance of center effects, theta < 10^-15", P > 0.5].

Crude 5- and 10-year CIR rates were 10.7% and 14.7% in MG patients and 11.1% and 15.7% in non-MG ones, respectively (Fig. 2). No significant differences were seen in patients with and without MG in stages III and IV CIR curves (Figure E2).

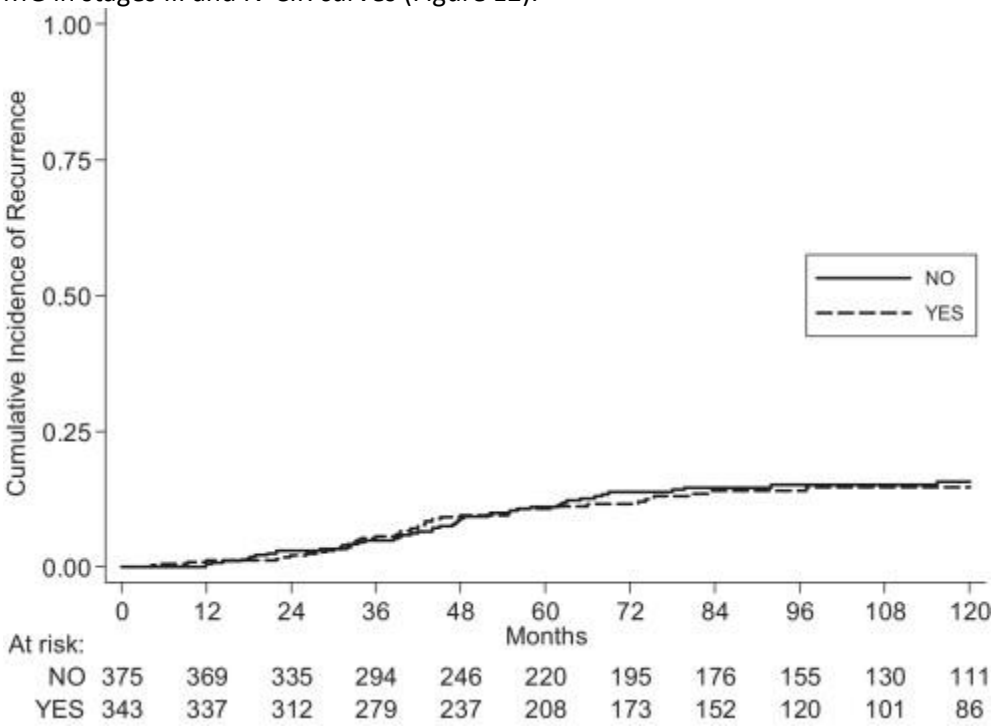


Fig. 2.

CIR for patients with and without MG.

Univariate model did not show any evidence of MG protective effect (adjusted HR: 0.95;95%CI:0.62-1.46,P = .827). Stages III-IV and preoperative therapy, only demonstrated to be independent prognostic variables (Table 3).

Table 3.

Cumulative incidence of recurrence. Fine & gray model for competing risk (N = 718).

Crude	HR(95%CI)	P
MG	0.89 (0.6 to 1.33)	0.582
Adjusted		
MG	0.95 (0.62 to 1.46)	0.827
Age (continuous)	0.99 (0.98 to 1.01)	0.348
Male	0.77 (0.51 to 1.16)	0.207
Masaoka Stage		
I (Ref)	1	–
II	2.19 (0.75 to 6.37)	0.151

Crude	HR(95%CI)	P
III	7.69 (2.48 to 23.83)	<0.001
IV	23.4 (7.9 to 69.32)	<0.001
Diagnosis		
Thymoma WHO A-AB-B1 (Ref)	1	–
Thymoma WHO B2-B3	0.98 (0.59 to 1.62)	0.942
Thymic carcinoma	1.04 (0.48 to 2.25)	0.921
Adjuvant Therapy	0.77 (0.42 to 1.4)	0.393
Induction Therapy	1.77 (1.05 to 2.99)	0.032

Finally, no strong evidence of outcome heterogeneity by different Institutions was found (variance of Center effects, theta < 10^-15"–Fig. E3).

4.4. Subgroup analysis by histology

Additional comparisons according to the MG presence adjusting for PS showed very similar results to those reported above: adjusted HR 1.02 (95%CI:0.74-1.40) for OS and HR 1.01 (95%CI:0.68-1.51) for CIR (Table 4). In addition, based on interaction p-values (P = 0.305 and P = 0.469 for OS and CIR, respectively), no strong evidence of an effect modification of MG by diagnosis subgroup was found.

Table 4.
Subgroup analysis by histologya.

	Overall Survival (N = 797)	CIR (N = 718)
	HR (95%CI)	HR (95%CI)
	MG present vs absent	MG present vs absent
All Patients	1.02 (0.74 to 1.40)	1.01 (0.68 to 1.51)
Diagnosis subgroup		
A-AB-B1	1.08 (0.66 to 1.75)	0.83 (0.43 to 1.60)
B2-B3	1.11 (0.69 to 1.80)	1.28 (0.70 to 2.35)
Thymic Carcinoma	0.45 (0.16 to 1.32)	0.57 (0.13 to 2.49)
	p interaction = 0.305	p interaction = 0.469

a
Comparisons by MG (present vs absent) are propensity score adjusted.

Fig. 1: OS for patients with and without MG.

5. Discussion

One of the well-known and interesting thymoma biological features is its frequent association with several autoimmune disorders, of which MG is by far the most common. MG has been considered as the prototype of organ-specific autoimmune disease, since autoantigens as well as autoantibodies are produced and dependency on T-helpers cells has also been demonstrated. However, it is actually unclear why MG is so frequent in thymoma.

Thymomas are immunologically functional because of their high incidence of paraneoplastic disorders, which lead to conclude that this neoplasm may be considered as an acquired thymus with an incomplete selection and immunological tolerance [14].
The present study represents one of the largest clinical series of thymoma patients operated in 6 high-volume General Thoracic Surgery Institutions, historically involved in thymic diseases management in Italy. This may guarantee a satisfactory uniformity in our results.

In our series, MG occurred in 375 patients (47%): lower MG percentages have been previously reported [11] and [15], probably depending on differences in patients' recruitment. Our

Institutions are, in fact, expert in MG patients' management, and a higher MG incidence may be therefore justifiable.
Concerning patients' clinical characteristics, our results seem to match those previously reported in the literature. In particular, MG patients are more frequently female and significantly younger than those without.

MG significantly correlates with B-type thymoma, and in our population, the majority are B2-B3. Evoli [16] and Okumura [17] first demonstrated that MG was frequently associated with AB-B1-B2 thymomas, which are functional tumors in term of T-cell maturation. Our results corroborate the hypothesis that WHO classification might reflect the thymoma immunological behavior, as previously described [18]. The high B3 thymoma percentage in our series could be in part related to the histopathological changes induced by a preoperative steroid medical treatment. The lymphoid component in a thymoma is well-known to be highly sensitive to steroid, and the drug administration might have changed the morphology of some B2 tumors into a comparable with that of B3 ones [16] and [19].
Our results show that thymomas with MG present at earlier stages than those without: this is probably imputable to an earlier thymoma diagnosis in those patients with neurological symptoms, because of their strict clinical/radiological follow-up. Moreover, due to the fact that more invasive thymoma occurs in non-MG patients, some Authors[14] postulated that tumors with and without MG might be considered as 2 distinct entities, and a more aggressive non-MG thymomas' biological behavior might be the cause of the different outcomes of the 2 diseases.
The association of thymoma with MG was reported to be an indicator of poor prognosis until the 1970s [20]; after the 1980s however, some papers demonstrated that this association was no longer a negative prognostic factor [21] and [22]. In our experience, we did not find any significant effect of MG on OS in adjusted model: the only independent predictors of outcome were age, tumor advanced stage, incomplete resection and thymic carcinoma histology. Absence of MG negative prognostic effects probably reflects the improvement of pre-intra and postoperative management of such complex patients, as well as long-term medical care [23] and [24].
Some older studies showed a lower CIR rates in thymoma with MG [9], [23] and [24]: in our, only Stages III-IV and preoperative therapy influenced CIR. Contrariwise, as in OS analysis, MG did not show any significant effects on recurrences development, both in univariate and adjusted models.
Possible study limitations are as follows:

1
the retrospective and multicenter design;

2
the high MG patients' percentage and the type of recruitment;

3
the long recruitment period.

Limitations' effects have been reduced by assessing within Centres correlation in the multivariable final model and including time effect in our analyses.

On the other hand, this study reflects the opportunity to collect a large series from Centers with high experience in TET and MG management.

In conclusion, thymomas with MG present at earlier stages than those without, and mostly in young and female patients. MG tumors are also more commonly associated with B2-B3 histotypes; lastly, MG seems not to influence survival and recurrence development.

Conflict of interest statement

All the authors declare that there are no conflict of interest concerning this manuscript

Funding

None declared

Appendix A. Supplementary data

Help with DOCX files

Options

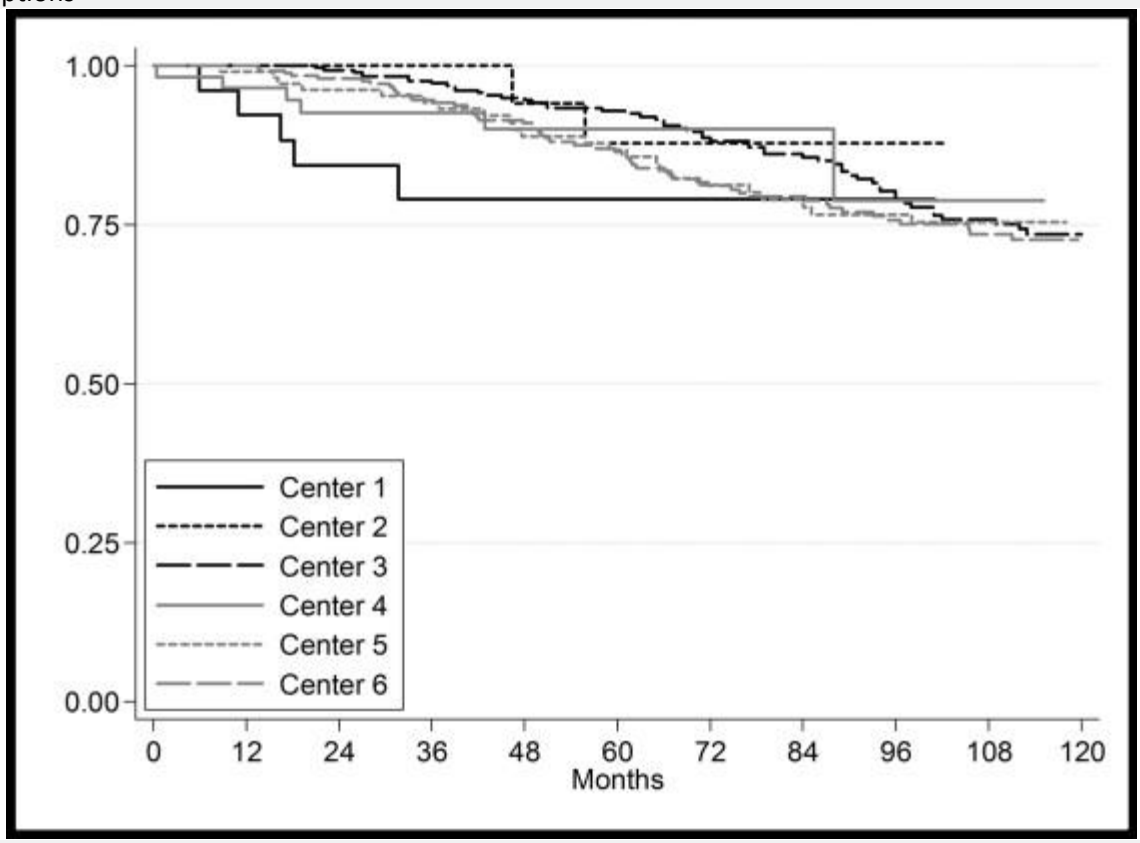


Figure options

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