ORIGINAL ARTICLE

INFECTIVE ENDOCARDITIS: A PROSPECTIVE REGISTRY OF SURGICAL LESIONS

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Abstract

Introduction: *Infective endocarditis morbidity and mortality remains high. Surgery is performed in about half of endocarditis cases, being the ideal setting to evaluate endocarditis lesions.*

The aim of this study was to register and describe endocarditis lesions found during surgery; find predictors of morbidity and mortality and correlate lesions found in echocardiogram vs. surgery.

Materials and Methods: *One hundred consecutive patients with endocarditis lesions seen during surgery were included between June 2014 and August 2018. Pathological lesions were coded prospectively using a coding form published by Pettersson et al. Other data were collected retrospectively.*

Results: *Prosthetic endocarditis accounted for 23% of cases. Embolic events had occurred in 41% of cases, mainly to the brain (22%). The most frequent lesions found in echocardiogram were vegetations (77%). Vegetations and valve integrity anomalies were the main lesions described during surgery (70% and 71% respectively). Invasion was present in 39% of patients. In-hospital mortality was 9%. In univariable analysis, predictors of early mortality included chronic kidney disease (P= .005), prosthetic valve endocarditis (P <.001), EuroSCORE II (P <.001) and valve integrity anomalies (P=.016). Predictors of embolic events included aortic valve vegetations seen during surgery (P= .026). Sensitivity and specificity of echocardiogram findings for identification of vegetations were 84% and 40%, for valve integrity anomalies 42% and 97% and for invasion 54% and 95%, respectively.*

Conclusions: *Diversity of lesions found in endocarditis precludes obtaining significant predictors of morbidity or mortality with small numbers of patients. Echocardiogram lacks sensitivity for valve integrity anomalies and invasion but is highly specific.*

Keywords: *infective endocarditis, Echocardiography, cardiac surgery, heart valve diseases*

INTRODUCTION

Infective endocarditis (IE) is a microbial infection of the valvular and nonvalvular endothelium of the heart. The classification of IE as acute is based on the clinical presentation and progression of untreated disease and pathogenic virulence. Although there have been alterations in the disease pattern over the years, morbidity and mortality remains high.[1] In most studies, endocarditis lesions found during surgery are not extensively described, being usually only classified as vegetations, abscess/cavity and cusp/leaflet tear. Its location, size and extension are poorly described.[2-4] As surgery is performed in about 50% of endocarditis cases[5], it is the ideal set to thoroughly evaluate endocarditis lesions.

The aims of this study were to describe clinical and surgical features, namely lesions, of patients submitted to surgery due to endocarditis; assess early and long-term mortality and its predictive factors and assess sensitivity and specificity of echocardiogram regarding diagnosis of endocarditis lesions, having surgery as the gold standard.

METHODS

All consecutive patients with endocarditis lesions (active or remote) at the time of surgery in a tertiary centre in Lisbon, Portugal were included. A total of 100 consecutive cases were included between June 2014 and August 2018. No patients fulfilling these criteria were excluded. Our department performs around 1000 major cardiac surgeries per year and receives patients referred from 7 centres.

Pathological lesions were defined and coded prospectively using a coding form suggested by Pettersson et al.6 where all endocarditis lesions are recorded according to type, location and size. The following definitions were considered:

- Active endocarditis: presence of vegetations, pus, or necrotic tissue.
- Remote endocarditis: no signs of active infection.
- Valve integrity anomalies: perforation: when preserved free margin as a result of infection; tear: torn or stretched margin as a result of infection.
- Anterior mitral leaflet jet or kissing lesion: infectious lesion on anterior mitral valve leaflet caused by regurgitant jet.
- Chord rupture: chord is ruptured as a result of infection.
- Invasive disease: infectious process extends beyond cusps or leaflets into annulus or surrounding structures.
- Invasion/abscess stage (>1 stage can be present): cellulitis: when invasion without collections of pus or microabscesses; abscess: when macroscopic collection of pus; abscess cavity: when cavity with debris and clots, suggesting active endocarditis; pseudoaneurysm: when endothelialized cavity without pus.
- Intervalvular fibrosa (subaortic curtain) destruction: involvement of subaortic curtain (contiguous aortic and mitral valve annuli).
- Atrioventricular (AV) node/bundle destruction: if patient has AV block and infectious pathologic destruction of AV node/bundle is present.

The coding form as well as the definitions were translated to portuguese and it was filled in with the surgical team mostly within one day after the surgery. Other data, such as medical history and diagnostic studies, was collected retrospectively through consultation of medical records. Echocardiogram information was retrieved from all available reports of echocardiograms (transthoracic- TTE or transoesophageal-TOE) performed before surgery within the endocarditis episode. Categories of lesions were grossly defined in the same way as surgical lesions. Preoperative embolic events were considered both when diagnosed through clinical (peripheral endocarditis lesions such as Osler nodes and Janeway lesions) or imaging findings from all available studies (abscess/infarction to brain, spleen, liver or lungs identified in computed tomography (CT) or magnetic resonance imaging (MRI) or extracardiac uptake in positron emission tomography (PET)-CT). Early mortality was defined as occuring less than 30 days after surgery.

This study was approved by the institutional research ethics committee on the 10th November 2021 under the code 21100 and was conducted in accordance with the principles set forth in the Helsinki Declaration. The need for informed consent was waived by the committee. The ethics committee is registered in the National Registry for Clinical Studies with the number 20170700050 and the chairperson is Paula M.R. Peixe, M.D.

Statistical analysis was performed with SPSS®. Categorical variables were reported as percentages and continuous variables as median/mean and standard deviation (S.D.). Univariable analysis was applied to both continuous and categorical variables. Comparison between continuous variables was calculated through t student's test and between categorical variables the chi-square test or Fisher exact test were used. A P value of .05 or less was considered significant. Cox regression was used for multivariate analysis to identify the independent predictors of mortality during follow up.

Table 1 **Preoperative characteristics**

	Median (minimum-maximum)
Age	62 (13-83)
	N=100 %
Male gender	72%
Heart failure	22%
Coronary artery disease	12%
Atrial fibrillation	25%
HBP	43%
Chronic lung disease	6%
Chronic kidney disease	10%
Dialysis	7%
Autoimmune disease	3%
Diabetes mellitus	18%
Obesity (BMI >30)	15%
Smoker (present/former)	36%
Neoplasia	13%
Immunosuppression	1%
Previous stroke	14%
Reduced mobility	17%
Device therapy (pacemaker/CRT)	6%
IV drug use	11%
Previous endocarditis	7%
LVEF - good function (>50%)	85%
- mild-moderate dysfunction (31-50%)	13%
- severe dysfunction (<31 %)	1%

BMI: body mass index; CRT: cardiac resynchronization therapy; HBP: high blood pressure; IV: intravenous; LVEF: left ventricle ejection fraction.

Table 2 **Clinical signs and preoperative complications**

	N=100 %
Fever	69%
Acute pulmonary edema	19%
NYHA III/IV	54%
Acute kidney disease under dialysis	6%
Peripheral endocarditis lesions	
Osler nodes	1%
Janeway lesions	6%
Embolic events	41%
pulmonary	9%
brain	22%
hemorrhagic stroke	3%
spleen infarction	18%
spleen abscess	1%
kidney	9%
peripheral	7%

NYHA: New York Heart Association

Table 3 **Imaging tests performed (apart from echocardiogram)**

		N=100 %
PET/CT		3%
	Cardiac uptake	1%
	Extracardiac uptake	2%
CT		37%
	No relevant findings	17%
	Cardiac lesions	1%
	Extracardiac lesions	19%
MRI		1%
	Extracardiac lesions	1%

CT: computed tomography; MRI: magnetic resonance imaging; PET: positron emission tomography

RESULTS

Population and preoperative variables

Most patients were male (72%) with a median age of 62 years (S.D. 15.8), with a minimum age of 13 and maximum of 83. Preoperative characteristics of patients are described in Table 1. Nosocomial/healthcare associated endocarditis occurred in 19% of cases. Native valve endocarditis represented 71% of cases and intracardiac device related endocarditis 6%. Among prosthetic endocarditis (23% of cases), approximately half were early cases (prosthesis implanted within less than a year) (n=12). Bicuspid aortic valve was found in 6 cases.

Clinical presentation of endocarditis and diagnostic tests

Clinical signs of endocarditis and its complications are described in Table 2. Fever was present in most patients at some point in the preoperative period. Peripheral endocarditis lesions (Osler nodes and Janeway lesions) were rarely identified. Embolic events were frequent, being found in almost half of the patients. However, imaging exams specifically directed for emboli diagnosis, such as PET-CT, CT or MRI, were only performed in 38% of patients (Table 3). Approximately half of CT scans demonstrated extracardiac lesions related with endocarditis (abscesses or infarction lesions). When embolism occurred, it was most frequently to the central nervous system and to the spleen. Central nervous embolism occurred both when mitral or aortic valves were involved (the aortic valve was involved in 50% and the mitral valve in 59%).

In preoperative blood analysis, considered as the last results available before surgery, most patients were anemic (mean hemoglobin value 10g/dL (S.D. 1.8); 94% hemoglobin levels ≤12g/dL and 67% ≤10g/dL). Mean creatinine was 1.83mg/dL (S.D. 1.7).

Microbiology

Most patients had positive blood cultures (72%), being Staphylococcus the most frequently identified organism (33%), followed by Streptococcus (21%) and Enterococcus (8%). Gram negative bacilli accounted for 4% of positive cultures. S. aureus represented 27% of positive cultures and coagulase negative staphylococci 8%. Streptococci species were mainly Strep. bovis and viridans (4 cases each). Gram negative bacilli included 2 cases of E. coli, 1 case of Pseudomonas aeruginosa, 1 of Proteus mirabilis and one patient had preoperative cultures positive for both Enterococcus faecium and K. pneumoniae.

Echocardiogram

All patients had at least one preoperative echocardiogram and 81% performed both TTE and TOE. Main findings are described in Table 4. The most frequent endocarditis lesions found were vegetations (77%) and approximately one third presented with valve integrity anomalies. Regurgitation was the most frequent valvular dysfunction (51% in aortic valve, 49% in mitral valve); however regurgitation in some cases (2% aortic and 19% mitral) were not related with infection of that specific valve.

Surgery: timing and indications

Mean time between diagnosis (initiation of antibiotics directed at a presumed/confirmed diagnosis of endocarditis) and surgery was 33 days (from 2 to 55 days, median 18 days). Remote IE was operated a median of 45 days after the acute episode. Some cases were diagnosed only during surgery as

Table 4 **Preoperative echocardiogram findings (transthoracic and/or transoesophageal**

Preoperative echocardiogram		N=100 %
Vegetations		77%
	Aortic	41%
	Mitral	35%
	Tricuspid	6%
	Pulmonary	1%
	Electrodes	4%
Invasion		24%
	Aortic	21%
	Mitral	3%
Valve integrity abnormality		31%
	Aortic	14%
	Mitral	20%
Regurgitation		83%
	Aortic	51%
	Mitral	49%
	Tricuspid	10%
	Pulmonary	1%
Stenosis		11%
	Aortic	8%
	Mitral	3%
Leak		11%
	Aortic	6%
	Mitral	5%
Prosthesis dehiscence		5%
	Aortic	2%
	Mitral	3%

remote endocarditis (no previous suspicion of past endocarditis), therefore the range of days between diagnosis of endocarditis and surgery varies between 0 and 751 days.

Indication for surgery was heart failure in 60 cases, embolism in 24 and uncontrolled infection in 16. Twenty five cases were redo operations, five of them were cases of recurrent endocarditis.

Lesions found during surgery

In 19 cases, endocarditis was plurivalvular. It was active in 77%. Vegetations and valve integrity anomalies were the most frequently described lesions (70% and 71% respectively). Invasion was present in 39% of patients.

Regarding aortic valve endocarditis, 25% were prosthetic valve infections (8 biological and 6 mechanical prosthesis). Mitral valve endocarditis involved native valves in 82%, repaired valves in 2% and prosthesis in 16% (4 biological and 4 mechanical prosthesis).

Endocarditis lesions found during surgery are summarized in Table 5. Regarding endocarditis of each valve individually, vegetations are still present in most cases for all valves (74% of aortic, 64% of mitral and 78% of tricuspid valve endocarditis). Vegetations and valve integrity anomalies do not seem to have a preferential location, as they distribute fairly evenly in each valve.

Anterior mitral leaflet jet lesion is not a frequently described lesion (14% of aortic valve endocarditis). Paraprosthetic leak is the most frequent lesion in prosthetic valve endocarditis.

Most specimens collected during surgery were sent to the microbiology department (results available in 97% of cases). Cultures were positive in 24 patients, mainly for Staphylococcus (n=15; S.aureus n=7 and coagulase negative staphylococci n=8), Enterococcus (n=5) and fungus (Candida) (n=4). Gram negative bacilli were isolated in 3 cases (E. coli and Pseudomonas aeruginosa). Patients with fungus isolated in valves had preoperative blood cultures negative or positive for bacteria.

Pathology analysis was performed in three cases and it confirmed the diagnosis in all of them.

Surgery

The most frequent surgical procedure performed was valve replacement. Aortic valve was mainly replaced by bioprosthesis (conventional biological prosthesis: n=24, stentless porcine aortic root: n=6, stentless pericardial prosthesis: n=4; mechanical prosthesis: n=25). Mitral valve was replaced in 43 cases (22 bioprosthesis and 21 mechanical), and repair was possible in 7 cases. The tricuspid valve was replaced in 3 cases (2 bioprosthesis and 1 mechanical prosthesis) and repaired in 10 patients. Other procedures simultaneously done were surgical extraction of pacemaker leads (n=6), coronary artery bypass graft (n=5) and abscess exclusion with a pericardial patch (autologous or bovine) (n= 30).

Survival/prognosis

Follow-up was complete in 99% cases (only one foreign patient was lost to follow up). The mean follow-up was 25 months (range 0-53; S.D. 16). In 5 cases, there was recurrence of endocarditis, all within 6 months after surgery. Four out of the 5 cases were re-operated. In-hospital and 30-day mortality were the same (9%) and were similar to the mean EuroSCORE II (9.36%). Early mortality (within 30 days after surgery) for active endocarditis cases was 11.7%. One-year mortality was 17% and death during follow up was 25%.

In univariable analysis, predictors of early mortality included age, prosthetic valve endocarditis and valve integrity anomalies found during surgery (Table 6). Identified predictors of mortality during follow-up in multivariable analysis were high blood pressure, NYHA III-IV heart failure, prosthetic valve endocarditis and chronic obstructive pulmonary disease (COPD)/asthma (Table 7).

Predictors of embolic events included vegetations on

echocardiogram (P= .009), aortic valve vegetations found during surgery (P= .026), reduced mobility (P= .001) and intravenous drug abuse (P= .007).

When comparing isolated microorganisms and type of lesions, morbidity or early mortality, no correlation could be found.

Lesions found in echocardiogram vs. lesions found in surgery

We compared lesions identified in echocardiogram (TOE + TTE) and lesions found during surgery. Considering surgery as the gold standard, we could also calculate sensitivity and specificity of echocardiogram for identification of endocarditis lesions (Table 8).

DISCUSSION

Endocarditis can present as a wide range of lesions and, in this study, we were able to describe them thoroughly during surgery. Only valve integrity anomalies were identified as a predictor of mortality, alongside comorbidities, such as chronic kidney disease, and prosthetic valve endocarditis. Vegetations in the aortic valve were associated with embolic events. Comparison between echocardiogram and surgery revealed a good sensitivity but low specificity for diagnosing vegetations, while the opposite occurred for valve integrity anomalies and invasion.

The incidence of IE has been described in the past years as being around 2 to 6 per 100,000 inhabitants.[1] Annual incidence in Portugal was recently reported as being 8.31 per 100,000.7 We identified 100 cases in about 4 years, which represents around 2.5% of our surgical cases per year. Our population is fairly similar to that described in literature regarding sex distribution (male to female case ratio described as more than 2:18) and mean age (55 years in the STS database[9], 58 years in the International Collaboration on Endocarditis (ICE) study10 and 59 in EURO-ENDO5).

Our population included some patients with fairly clearly identified risk factors for endocarditis, such as state of immunosuppression, chronic hemodialysis,[1, 8, 11, 12] presence of prosthetic valves,[13] intravenous drug use, intracardiac devices,[14] but the existence of a direct causative factor was not always clear. We had a higher proportion of native valve endocarditis than what was described in the EURO-ENDO study (71% vs. 56.6%).[5]

Clinical diagnosis requires a high index of suspicion as patients often present with nonspecific symptoms or complications of endocarditis.[12,15] Historically described lesions, such as Janeway lesions and Osler nodes are now rarely described, as diagnosis and treatment of endocarditis is made earlier.[8, 16]

Several pathogens may cause endocarditis, but Streptococcus spp., Staphylococcus spp., and Enterococcus spp. are responsible for more than 80% of all cases[1] (86% of all positive blood cultures in our population). S. aureus was the most frequently isolated organism (27% of our population), which is consistent with large series such as ICE-Prospective Cohort Study (ICE-PCS) and the EURO-ENDO where it accounted for 31% of all infections.[5, 10] Staphylococcus were also the most frequently isolated pathogen (36.6%) in a systematic review of Portuguese patients.[17]

Blood cultures are the most important laboratory test for the diagnosis of IE, as it guides antimicrobial treatment. If blood is drawn for three sets of cultures before antibiotics are started, in about 90% of cases, the pathogen will be identified.[8, 16] However, studies report lower rates of culture positive endocarditis. In the EURO-ENDO, only 79% of blood cultures were positive,[5] a value similar to the one found in our study (72%). Possible causes for negative blood cultures described in literature are early start of antibiotics, insufficient number of sets of cultures collected or infection with fastidious organisms that require a longer incubation period, special culture techniques, or specific assays, which are not always easily available.[18] As blood cultures for most patients were performed in another hospital, we cannot infer the specific reasons for negative results in our study.

Imaging tests are essential for diagnosis of IE and its complications. Cardiac CT and MRI have emerged as an important aid in the diagnosis of endocarditis complications.[12] Recently, PET scan has also been used to evaluate more complicated cases of endocarditis, especially in prosthetic valve or cardiac device infections.[12] However, imaging studies, apart from echocardiography, are still underused in IE, although they often detect embolic events which would have gone unnoticed. In the EURO-ENDO study, in ESC (European Society of Cardiology) members countries CT was performed in only 52% of patients.[5] Imaging studies other than echocardiography were only included in the diagnosis algorithm of endocarditis in the 2015 ESC guidelines,[19] so its use is still not common practice, but it is expected to change in the upcoming years.

Echocardiography is still the standard imaging method in IE. It may reveal vegetations, hemodynamic consequences of valvular dysfunction, paravalvular complications and also cardiac function.[13] Literature usually compares sensitivity and specificity of TTE vs. TOE and most recent large series only report lesions found in echocardiogram but not lesions found in surgery. In this study, we were able to evaluate general echocardiogram sensitivity and specificity (comparison between TTE and TOE was not a goal of this study), as we had direct visualization of lesions during surgery to use as gold standard. Therefore, we could conclude that echocardiogram is most sensible for detection of vegetations (84%), consistent with literature (75-90%20), but it was not very specific (40%). This could be because we registered lesions found in any echocardiogram within the endocarditis episode, so antibiotic therapy might have eliminated some of the vegetations found in earlier echocardiograms. However, when analysing each valve individually, specificity is higher (between 82% for mitral valve and 99% for tricuspid valve).

Regarding valve integrity anomalies, accuracy of echocardiogram is seldom described in literature and num-

Table 5 **Lesions found during surgery**

	Aortic (n=58)	Mitral (n=50)	Tricuspid (n=9)	Pulmonary (n=1)
Affected valve		77%		
Native	76%	82%	100%	100%
Native repaired	-	2%	-	-
Prosthetic	24%	16%	-	-
Disease activity				
Active	78%	74%	89%	100%
Remote	22%	26%	11%	-
Anuloplasty ring		2%	-	
Vegetations present	74%	64%	78%	100%
Largest vegetation (mm)	40	50	30	15
Location of vegetations				
Right cusp	45%			100%
Left cusp	46%			100%
Non coronary cusp	46%			-
Anterior leaflet		36%	33%	
Posterior leaflet		32%	44%	
Septal leaflet			44%	
Anterior chord		6%	22%	
Posterior chord		6%	44%	
Septal chord			56%	
Valve integrity abnormality	**62%**	**68%**	**78%**	**100%**
Right cusp				
None	69%			
Perforation	14%			
Tear	18%			
Left cusp				
None	71%			
Perforation	16%			
Tear	14%			
Non coronary cusp				
None	71%			
Perforation	16%			
Tear	14%			
Anterior leaflet				
None		68%	56%	
Perforation		16%	11%	
Tear		16%	33%	
Posterior leaflet				
None		70%	67%	
Perforation		6%	-	
Tear		24%	33%	

	Aortic (n=58)	Mitral (n=50)	Tricuspid (n=9)	Pulmonary (n=1)	
Septal leaflet					
None			67%		
Perforation			11%		
Tear			22%		
Anterior chord					
None		84%	89%		
Rupture		16%	11%		
Posterior chord					
None		86%	100%		
Rupture		14%	-		
Septal chord					
None			89%		
Rupture			11%		
Anterior mitral leaflet jet lesion	14%				
Invasion	43%	30%			
Invasion location	Anterior 12%	Antero-lateral 10%			
	Left 19%	Postero-medial 16%			
	Posterior 21%				
Invasion stage					
Cellulitis	0%	12%			
Abscess	19%	2%			
Abscess cavity	12%	4%			
Pseudoaneurysm	12%	12%			
Circumferential extent					
< 1/3	21%	18%			
1/3-1/2	21%	8%			
Full circumference	2%	4%			
Intervalvular fibrosa destruction			9%		
AV node/bundle destruction (if known AV block)			4%		
Cavity depth (if applicable)	Shallow 17%	Shallow 16%			
	Deep (>1cm) 22%	AV groove involvement 2%			
Fistula destination (if applicable)	To right atrium 2%	To right atrium 2%			
	To left atrium 2%	To right ventricle 0%			
	To right ventricle 2%	Perforation to pericardium 0%			
	To left ventricle 5%				
Prosthetic valve	n=14	n=9			
Restriction of disc/ball	7%	11%			
Paraprosthetic leak	57%	67%			
Unstable/ rocking	14%	11%			
Ascending aortic graft infection	7%				
Infected pacer leads (n=6)	Right atrium	Right ventricle	Tricuspid valve	Pocket	Epicardial
Infected	17%	50%	50%	-	-
Largest vegetation (mm)		50			
Other site (vegetations)				Largest size (mm):-	

bers of reports are usually low. In one study, sensitivity of TTE for detecting valvular perforation was 45% and 95% for TOE, and the specificity was 98% for both techniques.[21] We obtained a quite low sensitivity (42% in general and between 39% and 56% for aortic and mitral valve respectively), but a high specificity (>95%). Concerning invasion, the reported sensitivity of echocardiogram is about 50%-90%, and specificity can be higher than 90%,[20] which is consistent with the low sensitivity and high specificity we also describe.

Embolic events are one of the main complications of endocarditis and may occur in up to 50% of patients with IE, mainly to the central nervous system. They may not be apparent in up to 25% of cases, being only detected in imaging studies.[13,14,16] In the EURO-ENDO study, embolic events were the most frequent complication, observed in 20.6% of patients.[5] In our population, there was a higher rate of embolism (41%). However, 72% of patients without described embolic events had no imaging tests, so many embolic events might have gone undetected. As expected, the presence of vegetations, mainly in aortic valve, proved to be a predictor of embolism.

IE mortality has been reported as 15-22% for in hospital mortality (18% in the ICE-PCS, 8.2% in the STS database, 17.1% in EURO-ENDO) and 20-30% at one year.[5, 8,9,13] Patients who undergo surgery will have a mortality rate of 9% if operated electively, but when surgery is performed urgently, mortality raises up to 25-35%.[22] In the EndoSCORE study, which included 2715 endocarditis patients, early mortality was 11.0%.[23] A study performed in our centre with endocarditis patients submitted to surgery between 2007 and 2014 stated a perioperative mortality of 16%.[24] This population only included active endocarditis, as all surgeries were urgent/emergent. However, mortality in active endocarditis cases in our series was still lower (11.7%). Other studies in Portugal with surgical series of endocarditis patients also reported a mortality between 13.1% and 15.5%. The lowest mortality was reported by the most recent study (period of 2006/2017).17 Our early mortality rate was 9%. This may represent the improvement in cardiac surgery outcomes and perioperative management of these patients in recent years.

The predictors of mortality we identified are already described in literature, such as prosthetic valve endocarditis, renal failure and reoperation,[5, 8-10, 13, 23] except for valve integrity anomalies found during surgery. Most series that describe surgical lesions are usually not very exhaustive. Lesions are grossly described as vegetations or abscesses and localized only in relation to the valve involved. To our knowledge, detailed description of lesions as is reported by us has not been reported before.

Lesions found during surgery were diverse and consequently the numbers for each were mostly incapable of revealing any statistically significant relations with mortality, embolic events, and causative organism. However, its detailed description points out that lesions distribute evenly in the valves and confirms the more aggressive invasiveness in aortic valve endocarditis. Although it might seem that not much new information could be retrieved from these data regarding morbidity and mortality, the pursuit of detailed registry of lesions could eventually lead to better understanding of endocarditis, its diagnosis and aid in its treatment.

Table 6 **Predictors of early mortality – univariable analysis (chi square and t student tests)**

Predictors of early mortality	
Age	P= .011
High blood pressure	P= .005
Chronic kidney disease	P= .005
NHYA III-IV heart failure	P= .003
Valve integrity anomalies (surgery)	P= .016
Prosthetic endocarditis	P< .001
Redo operation	P= .001
Euroscore II	P< .001

Statistical significance for P<0.05. NYHA: New York Heart Association

Limitations of this study are mainly related to the small numbers, which leads to non-statistical significance for lesions and microorganisms involved. The small number of events for relevant variables did not allow the performance of multivariable analysis for early mortality nor embolic events. The fact that most specimens collected during surgery were not sent for pathology analysis and the fact that the activity of the disease was determined only by the surgeons' description of the lesions found is also a limitation of this study. Another constraint was the sometimes-scarce information obtained from other institutions about the preoperative period. We also did not have access to cause of death after discharge.

CONCLUSION

This study provides a detailed description of endocarditis lesions found during surgery in 100 consecutive patients in a tertiary hospital. The only lesions found as having impact in morbidity or mortality were valve integrity anomalies (predictor of early mortality) and aortic valve vegetations (predictor of embolic events). No correlation between endocarditis microorganisms and type of lesions or morbidity/mortality was found. Correlation of lesions found in surgery and echocardiogram reveals that echocardiogram lacks sensitivity for valve integrity anomalies and invasion but is highly specific. Despite the difficulties with detailed description of IE lesions found during surgery, understanding, and better correlating the pathologic operative findings with the clinical and echocardiographic presentation, may lead to more accurate and early diagnosis of IE, optimal choice of surgical techniques and improvement of patient outcomes. This study is just a preliminary one regarding these goals.

Table 7 **Predictors of mortality during follow up**

Variable	Univariable analysis P value	Multivariable analysis		
		HR	CI 95%	P value
Age	0.001			
High blood pressure	<0.001	14.07	3.33-59.49	< 0.001
NHYA III-IV heart failure	0.003	6.52	1.59-26.78	0.009
Prosthetic valve endocarditis	0.02	3.39	1.14-10.09	0.028
Previous stroke	0.04			
COPD/asthma	0.033	5.54	1.25-24.67	0.025
Acute renal failure with RRT	0.033			
Surgery due to heart failure	0.005			

COPD: chronic obstructive pulmonary disease; NYHA: New York Heart Association; RRT: renal replacement technique

Table 8 **Sensitivity and specificity of echocardiogram for identification of endocarditis lesions in all valves and in the aortic, mitral, and tricuspid valve, considering surgery as the gold standard**

Echocardiogram (N=100)		Vegetations	Valve integrity anomaly	Invasion
All valves	Sensitivity	84.3%	42.3%	53.8%
	Specificity	40%	96.6%	95%
	Positive predictive value	76.6%	96.8%	87.5%
	Negative predictive value	52.2%	40.6%	76.3%
Aortic valve	Sensitivity	74.4%	38.9%	66.7%
	Specificity	84.2%	100%	95.9%
	Positive predictive value	78.1%	100%	85.7%
	Negative predictive value	81.4%	74.4%	88.6%
Mitral valve	Sensitivity	71.9%	55.9%	23.1%
	Specificity	82.4%	98.5%	100%
	Positive predictive value	65.7%	95%	100%
	Negative predictive value	86.2%	81.3%	89.7%
Tricuspid valve	Sensitivity	71.4%	-	-
	Specificity	98.9%	-	-
	Positive predictive value	83.3%	-	-
	Negative predictive value	97.9%	-	-

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