

## Original Investigation Reports

## National Registry of Intraoperative/Intraprocedural transesophageal echocardiography

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## ABSTRACT

This national registry represents the first systematic survey on the use of transesophageal echocardiography (TEE) in cardiovascular surgery and interventional cardiology procedures in Argentina. A multicenter survey was conducted among members of the Argentine Federation of Cardiology, with responses obtained from 32 centers across 16 provinces. Results showed that 68.8% of centers use TEE in cardiovascular surgery and 78.1% in structural procedures, although limitations remain related to insufficient equipment, trained personnel, and standardized protocols. Only half of the centers reported access to three-dimensional technology, and a similar proportion had institutional guidelines for TEE implementation. Most procedures did not report major complications, confirming the safety of the technique. These findings highlight the growing adoption of TEE in Argentina, though with regional heterogeneity, and underscore the need to strengthen interdisciplinary training and to develop national consensus recommendations adapted to local healthcare settings.

## INTRODUCTION

Using transesophageal echocardiogram (TEE) is increasingly more frequent in the fields of the OR and catheterization laboratories.<sup>1</sup> However, in Argentina, there are scarce data published. Use of TEE in ORs and catheterization laboratories adds additional challenges, proper of the scenario: who is in charge of performing the test, what are the indications, procedure standardization, device management, detection and management of complications.<sup>2,3,4,5</sup> On the other hand, access to more modern technologies, such as 3D images, is very promising but unequal in the different centers using TEE in the OR and/or catheterization laboratory.<sup>6</sup>

Plenty of international medical societies have concerned themselves to describe these data. It is essential to have our own information available in our country.<sup>7,8</sup>

## AIMS

To determine the frequency of use of transesophageal echocardiogram both at intraoperative level and intraprocedural level in interventional cardiology, as well as indications of use, time during procedure and possible complications.

## MATERIALS AND METHODS

A survey was carried out with multiple choice questions, where echocardiography cardiologists participated, all members of the

societies that are part of the Argentine Federation of Cardiology (FAC) (*Annex, Table 1*). Since its dissemination, carried out by direct phone contact with the professionals, and reinforced by e-mail through FAC, a period was determined to complete it, from September to December 2024. Starting from it, a multicenter, prospective, observational, cross-sectional study was developed.

## Registry inclusion criteria

Patients with ages greater or equal to 18 years, in whom transesophageal echocardiogram was carried in a scenario of heart surgery or structural interventional cardiology procedure.

## Definitions

- Heart surgery: myocardial revascularization surgery, valve replacement surgery, aortic surgery, valvuloplasty, surgical correction of congenital heart disease, heart transplant.
- Structural interventional cardiology procedure: percutaneous repair of the mitral or tricuspid valve, percutaneous implant of the aortic, pulmonary, mitral or tricuspid valve, percutaneous closure of left atrial appendage.

## Statistical analysis

A descriptive analysis was made on the answers to the survey. Categorical variables are expressed as percentages and were compared by the Chi-square test. Continuous variables are presented,

## ANNEX

## CENTER DATA

- Name of the center
- Province
- City
- In average, how many heart surgeries in adults are made in your center yearly?
- In average, how many procedures of structural interventional cardiology in adults are made in your center yearly?
- Is intraoperative transesophageal echocardiography conducted in your center?
- Is SHD intraprocedural (TAVI, appendage closure, mitral valve repair, etc.) echocardiography conducted in your center?

## IF INTRAOPERATIVE/INTRAPROCEDURAL TEE IS NOT PERFORMED IN YOUR CENTER

- The reason not to do it is mainly:
  - It is not considered necessary.
  - There is no necessary equipment available.
  - There is no necessary staff available.
  - Another reason.
- Are you thinking about starting to use intraoperative/introprocedural TEE in your center soon?

## INTRAOPERATIVE TEE

- About the person in charge of carrying out the TEE, what is their specialty? Cardiology, anesthesiology, surgery/hemodynamics, technician.
- About the person in charge of placing the TEE probe, what is their specialty? Cardiology, anesthesiology, surgery/hemodynamics, technician.
- Does TEE have 3D mode?
- In what percentage of mitral valvuloplasties is TEE used?
- In what percentage of valve replacements is TEE used?
- In what percentage of on-pump coronary artery surgeries is TEE used?
- In what percentage of off-pump coronary artery surgeries is TEE used?
- In what percentage of combined surgeries is TEE used?
- In what percentage of heart transplants is TEE used?
- In what percentage of aortic surgeries is TEE used?
- Is there a specific TEE protocol in use in your center?
- In general, how many times is TEE used during surgery? Before, during, at the end, when pumping ends.
- How frequently did TEE modify the surgical strategy during surgery? Never, a few times, most of times, always.
- Are the videos and images obtained during TEE stored?
- Is the TEE report made?
- Did a complication threatening the life of patients ever occur? No, esophageal perforation, bleeding, another.

## INTRAPROCEDURAL TEE

- About the person in charge of performing the TEE, what is their specialty? Cardiology, anesthesiology, surgery/hemodynamics, technician.
- About the person in charge of placing the TEE probe, what is their specialty? Cardiology, anesthesiology, surgery/hemodynamics, technician.
- Does TEE have 3D mode?
- In what percentage of percutaneous aortic valve implantations is TEE used?
- In what percentage of percutaneous mitral valve repairs is TEE used?
- In what percentage of LA appendage closures is TEE used?
- In what percentage of percutaneous tricuspid valve repairs is TEE used?
- In what percentage of percutaneous pulmonary valve implantations is TEE used?
- In what percentage of septal ablations is TEE used?
- In what percentage of congenital diseases procedures in adults is TEE used?
- Is there a specific TEE protocol available in your center?
- In general, how often is intraprocedural TEE used? Before, during, at the end.
- With what frequency did TEE modify the surgical strategy during surgery? Never, a few times, most of times, always.
- Are the videos and images obtained during TEE stored?
- Is the TEE report made?
- Did a complication threatening the life of patients ever occur? No, esophageal perforation, bleeding, another.

## USE OF TEE

- How frequently is TEE used for the following? (Never, sometimes, frequently, always)
  - Adjustment of pharmacotherapy
  - Help in device placement (IABP, ventricular assist device, etc.)
  - Evaluation of valve disease
  - Post-bypass evaluation
- Is TEE used to evaluate the following parameters? Never, sometimes, frequently, always.
  - Left and right ventricular function
  - Contractility anomalies
  - Diameters
  - Valve function
  - Diastolic function
  - Presence of patent foramen ovale
  - Intracardiac thrombi
  - Atheroma and aortic dissection.

**TABLE 1**  
Answers by province.

| Province            | Frequency | Percentage (%) |
|---------------------|-----------|----------------|
| Buenos Aires        | 3         | 9.4            |
| Chaco               | 2         | 6.3            |
| Chubut              | 1         | 3.1            |
| Córdoba             | 4         | 12.5           |
| Corrientes          | 1         | 3.1            |
| Entre Ríos          | 2         | 6.3            |
| Formosa             | 2         | 6.3            |
| Jujuy               | 1         | 3.1            |
| La Pampa            | 1         | 3.1            |
| Mendoza             | 2         | 6.3            |
| Misiones            | 2         | 6.3            |
| Neuquén             | 1         | 3.1            |
| Salta               | 1         | 3.1            |
| Santa Fe            | 7         | 21.9           |
| Santiago del Estero | 1         | 3.1            |
| Tucumán             | 1         | 3.1            |
| <b>TOTAL</b>        | <b>32</b> | <b>100</b>     |

according to their distribution, as mean and standard deviation or median and interquartile range, and compared by Student's t-test or Mann-Whitney U test as it may correspond. A p value of  $<0.05$  in all analysis was considered statistically significant. All statistical analyses were made by the IBM SPSS Statistics 25 software.

#### Data capture and safety

An advanced system of electronic capture of data through the Internet was used, with https:// connection for a safe transfer of

information. Data were encoded during the Internet transfer and saved in a database protected against unauthorized access.

#### RESULTS

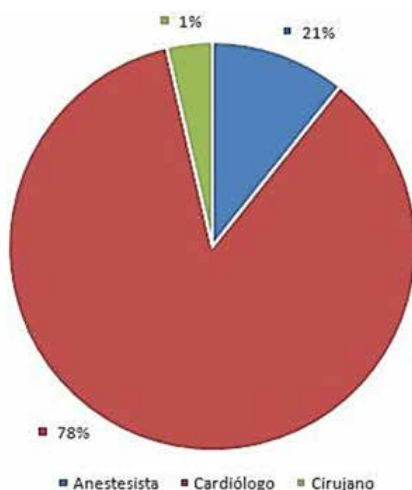
Replies were obtained from 32 centers, with Santa Fe being the province that most contributed with 7 centers, followed by Córdoba with 4 centers and Buenos Aires with 3 centers (*Table 1*). As the two first provinces represented 34% of the surveyed, they were analyzed jointly compared to the rest of the country, with no statistically differences being found in terms of use of TEE in the OR or in catheterization laboratories.

In regard to the interventions made, 3 centers replied that they do not conduct cardiothoracic and vascular surgeries (CTVS), and 3 centers that they do not conduct structural heart disease procedures (SHD). The median of CTVS performed was 70 (IQR 85) and of SHD procedures 19 (IQR 40).

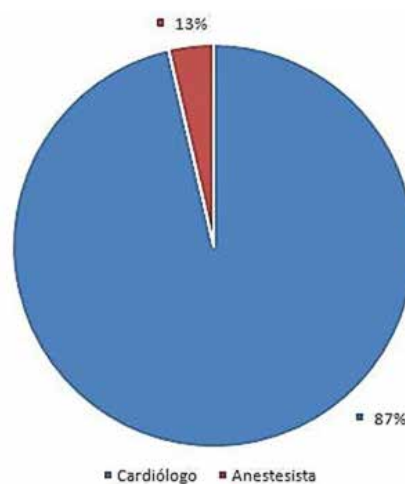
As to TEE, 25 centers (87.1%) replied that they carry it out during SHD procedures. From those that do not do it, 4 do not consider it necessary, 2 do not have the appropriate equipment, and 1 does not have the required staff. In the field of CTVS, 22 centers perform it (68.8%). From those that do not do it, 4 do not consider it necessary, 3 do not have the appropriate equipment, and 3 do not have the required staff. In both cases, 7 centers are considering using TEE in the short term.

In Argentina, the preparation for the procedure presents a different reality from other parts of the world, as the person in charge of performing the TEE, both in the OR and the catheterization laboratory, is mainly a cardiologist (*Figures 1 and 2*). A similar distribution is observed at the time of placing the probe, although with more participation of anesthesiologists (15.6% in SHD and 25% in CTVS).

When analyzing technical issues of TEE use, only half of centers have 3D mode; specific protocols are made in 64% of SHD and 72% of SHD. At the time of storing images, this is carried out in 96% of SHD and 95% of CTVS; while reports are made in 80 and 77% of tests for SHD and CTVS, respectively. In regard to complications, only one case of bleeding was recorded in the OR;



**FIGURE 1.**  
Person in charge of performing TEE in the operation room



**FIGURE 2.**  
Person in charge of performing TEE in the catheterization laboratory

while in the catheterization laboratory, 1 case of bleeding and 1 case of esophageal perforation.

### Uses of TEE

In *Table 2*, details are given on uses of TEE in cardiovascular surgeries, reflecting its predominant use in mitral valvuloplasty and isolated cases of valve replacements, surgical correction of congenital heart diseases and aortic surgeries. As to the time to use it, 59% do it before, 33% during and 36% when the surgery ends, and 36% at the time of ending extracorporeal circulation; thus, only 15% of centers use TEE in all the surgical times (35% use it only at a time and 50% in two times). From all the surveyed, 63.6% reported that TEE modified surgical behavior only a few times (22.7% most of the times, 4.5% never).

In *Table 3*, details are given on the use of TEE in procedures of structural heart disease, where it is manifest that most of its use is in procedures to close the left atrium appendage and closure of periprosthetic leaks. Another relevant piece of information is that, in our country, centers that do not perform percutaneous

mitral valve or tricuspid valve repairs, or pulmonary valve implants, are a majority. Remarkably, centers that do perform these practices do not use TEE in all procedures. As to the time of using it, 56% do it before, 20% during and 15% at the end of the procedure, making a total of 44% of centers that use TEE at all times of the procedure (28% at just one time). Only 12% of the surveyed reported that TEE always modified their management (4% never, 40% a few times, and 36% most of times).

During the survey, there were also questions about the use of TEE to estimate parameters other than those needed to guide CTVS or SHD procedures. Results are presented in *Table 4*. The parameters that are predominantly evaluated are left ventricular ejection fraction, valve function and the presence of intracavitary thrombi and/or aortic dissection. In regard to diastolic dysfunction, 71% of cases are evaluated a few times or never.

### DISCUSSION

This registry constitutes the first national endeavor to characterize the use of transesophageal echocardiography (TEE) in an

**TABLE 2.**

Use of TEE in cardiovascular surgery.

|               | Mitral valvuloplasty (%) | Valve replacement (%) | MRS w/o ECC (%) | MRS w/ECC (%) | Combined surgeries (%) | Congenital heart disease surgeries (%) | Heart transplant (%) | Aortic surgery (%) |
|---------------|--------------------------|-----------------------|-----------------|---------------|------------------------|----------------------------------------|----------------------|--------------------|
| 0%            | 4.5                      | 22.7                  | 59.1            | 59.1          | 18.2                   | 22.7                                   | 13.6                 | 31.8               |
| 1-24%         | 22.7                     | 40.9                  | 9.1             | 13.6          | 40.9                   | 27.3                                   | 4.5                  | 31.8               |
| 25-49%        | 9.1                      | 9.1                   | 4.5             | 4.5           | 4.5                    | 9.1                                    | 0                    | 18.2               |
| 50-74%        | 4.5                      | 4.5                   | 0               | 0             | 4.5                    | 4.5                                    | 0                    | 0                  |
| 75-99%        | 4.5                      | 4.5                   | 0               | 0             | 4.5                    | 4.5                                    | 0                    | 0                  |
| 100%          | 27.3                     | 4.5                   | 0               | 0             | 4.5                    | 0                                      | 0                    | 9.1                |
| Not performed | 22.7                     | 13.6                  | 27.2            | 22.7          | 22.7                   | 31.8                                   | 81.8                 | 9                  |

MRS: myocardial revascularization surgery. ECC: extracorporeal circulation.

**TABLE 3.**

Use of TEE in structural heart disease procedures.

|               | Percutaneous aortic valve implantation (%) | Percutaneous mitral valve repair (%) | Percutaneous tricuspid valve repair (%) | LA appendage closure (%) | Periprosthetic leak closure (%) | Percutaneous pulmonary valve implantation (%) | Septal ablation with alcohol | Congenital heart diseases repair |
|---------------|--------------------------------------------|--------------------------------------|-----------------------------------------|--------------------------|---------------------------------|-----------------------------------------------|------------------------------|----------------------------------|
| 0%            | (%)                                        | 4                                    | 0                                       | 0                        | 0                               | 0                                             | 12                           | 0                                |
| 1-24%         | 36                                         | 8                                    | 0                                       | 12                       | 8                               | 8                                             | 16                           | 16                               |
| 25-49%        | 4                                          | 4                                    | 0                                       | 0                        | 4                               | 4                                             | 0                            | 20                               |
| 50-74%        | 4                                          | 0                                    | 4                                       | 0                        | 0                               | 0                                             | 0                            | 0                                |
| 75-99%        | 8                                          | 4                                    | 0                                       | 8                        | 4                               | 0                                             | 0                            | 8                                |
| 100%          | 4                                          | 16                                   | 8                                       | 52                       | 44                              | 8                                             | 20                           | 24                               |
| Not performed | 16                                         | 64                                   | 88                                      | 28                       | 40                              | 80                                            | 52                           | 32                               |

intraoperative and SHD intraprocedural scenario in Argentina. The results show that, although most centers report using TEE in cardiovascular surgery (68.8%) and in SHD procedures (78.1%), there are still limitations linked to equipment availability, training of human resources and the existence of standardized protocols.

These findings are in agreement with what the American Society of Echocardiography has pointed out, in collaboration with the Society of Cardiovascular Anesthesiologists and the Society of Thoracic Surgeons, where the role of TEE is emphasized as an essential tool to make intraoperative decisions, with an impact on safety and surgical results.<sup>1</sup> Particularly, international evidence has shown that a systematic use of TEE allows optimizing the evaluation of valve repairs, guide the implantation of prosthesis and detect complications in real time; aspects that in this survey were reported as factors that modified behavior in a limited number of cases.

Likewise, the recent publication of the American Heart Association on the intraoperative use of TEE in heart surgery underscores the need to have specific protocols and interdisciplinary training, aspects that in Argentina appear as inadequate.<sup>9</sup> In this registry, only half of the centers reported having a standardized protocol, and a similar percentage of devices with 3D echocardiography, reflecting a gap in regard to international recommendations.

Another relevant finding is the predominance of cardiologists as the person in charge of the procedure, both in the OR and in catheterization laboratories, in contrast with the usual practice in the United States and Europe, where anesthesiologists have a more central role. Another aspect poses a deeper analysis, as it reflects the organization of health care teams in Argentina, while the importance of encouraging joint training and multidisciplinary work stands out.

Finally, the low incidence of complications reported in this registry agrees with the previous literature, in terms of describing TEE as a safe technique, although not free from risks when carried out without the appropriate experience. The heterogeneity observed between centers, both in the frequency of use and in the times of implementing it during procedures, highlights the need to promote training programs, national consensuses and institutional policies oriented toward guaranteeing the universal availability of this tool.

Jointly, the results obtained allow to place Argentina in line with a growing tendency in the adoption of TEE in cardiovascular practice, although they show the need to strengthen organizatio-

nal, educational and technological aspects to reach international standards. This registry constitutes a valuable starting point for future multicenter studies and for the development of local guidelines adjusted to the national health care reality.

### Limitations

The main limitation of this survey is the scant number of participating centers. Although the initial invitation was through direct phone contact with 60 professionals, later invitations were sent by e-mail to all FAC members, so the final percentage of responders in relation to the total number of invitations is unknown. Anyway, responses were obtained from 16 provinces (67%), so the survey is considered wide enough to represent the reality of the whole country in the socioeconomic spectrum.

Second, we do not have the information discriminated by center in regard to the number of each type of surgery or each type of structural heart disease procedure. It was decided not to add questions in this sense to prevent inaccurate information or that may turn the collection and subsequent replying tedious.

As the survey was distributed from a federation of cardiologists, there may be a bias as the replies were predominantly provided by this group of professionals, so the centers where TEE are being made by anesthesiologists may be inaccurately represented.

### CONCLUSIONS

In this survey, TEE was used in 69% of CTVS and 78% of SHD procedures, mainly being carried out by echocardiography cardiologists, with indications similar to those described internationally, as well as a similar frequency of complications.

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TABLE 4

Parameters evaluated during use of TEE

|            | LVEF (%) | Contractility (%) | RVSF (%) | Dimensions (%) | Valve function (%) | Diastolic function (%) | PFO (%) | Thrombi (%) | RA Atheromatosis (%) | AO dissection (%) |
|------------|----------|-------------------|----------|----------------|--------------------|------------------------|---------|-------------|----------------------|-------------------|
| Never      | -        | -                 | -        | 8,7            | -                  | 21,7                   | 4,3     | 4,3         | 9,1                  | 4,3               |
| Sometimes  | 8,7      | 13,0              | 21,7     | 39,1           | -                  | 47,8                   | 17,4    | 4,3         | 13,6                 | 21,7              |
| Frequently | 26,1     | 39,1              | 39,1     | 17,4           | 34,8               | 13,0                   | 30,4    | 21,7        | 22,7                 | 8,7               |
| Always     | 65,2     | 47,8              | 39,1     | 34,8           | 65,2               | 17,4                   | 47,8    | 69,6        | 54,5                 | 65,2              |

LVEF: left ventricular ejection fraction; RVSF: right ventricular systolic function; PFO: patent foramen ovale; DA: descending aorta; Ao: aortic.

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