Assessment of tissue Doppler parameters via transesophageal echocardiography: how necessary?

Doku Doppler parametrelerinin transözafajiyal ekokardiyografi ile değerlendirilmesi: Ne kadar gerekli?

Transthoracic (TTE) and transesophageal (TEE) echocardiography are still the most common imaging modalities in clinical practice. Some imaging methods have been devised for the direct assessment of myocardial function in real time and offline. They allow objective assessment of regional and global left and right ventricular function and have improved the reliability in echocardiography studies. In 1971, Side and Josling (1) first described TEE as a way of recording continuous-wave Doppler velocities of cardiac flow. Since then, there have been significant advances in TEE as parallel to the ones in TTE, and TEE became an indispensable cardiac imaging technique. Today usefulness of TEE and its superiority over transthoracic echocardiography in imaging of cardiovascular structures have been well established.

In addition to its use in clinical practice, TEE has increasingly been used as intraoperatively in cardiac and non-cardiac surgery and plays an important role in interventional laboratory for percutaneous interventions. It is especially useful in patients undergoing valve repairs, replacements and reoperative surgeries (2). Intraoperative TEE is also very useful for the surgeons in making a decision about the choice of the surgical procedure, providing useful information for changing the preoperative plan and making a revision. TEE is also valuable for intraoperative monitoring of hemodynamics and assessment of systolic and diastolic myocardial function in the intraoperative setting (3-6). In recent years, intraoperative evaluation of myocardial function using TEE has become a routine practice in cardiac and non-cardiac surgery.

Myocardial functions can be evaluated using tissue Doppler parameters as well as conventional echocardiographic methods. Tissue Doppler echocardiography was introduced in 1994 and has since been proven to be a more sensitive technique in detection of subtle changes of systolic and diastolic myocardial function. Tissue Doppler parameters are not dependent on endocardial definition and less dependent on loading conditions. Doppler-based strain, strain rate and Tissue tracking imaging were derived from color Doppler tissue echocardiography and have been in use since 1999. This technique provides a noninvasive quantification of myocardial deformation and overcomes the tethering of abnormal myocardial segments by adjacent normal segments (7). Myocardial strain is the percentage of changes in the length of a myocardial segment. Strain rate is the rate at which the myocardium length changes. But this is a one-dimensional technique and has the disadvantage of angle-dependency of the measurements (8). Non-Doppler strain or speckle tracking echocardiography, introduced in 2004, is conducted by processing conventional 2D images. It enables an objective assessment of longitudinal (apex to base), radial (endocardium to epicardium), and circumferential (three deformation axes are orthogonal to each other) myocardial deformations (9). In contrast to tissue Doppler-derived parameters, speckle tracking is not angle-dependent as the movement of speckles can be followed in any direction.

As explained above, also because of increasing use of TEE intraoperatively, many studies have been carried out so far about intraoperative TEE. In these studies, feasibility and reproducibility of evaluation of left or right ventricular functions by tissue Doppler echocardiographic methods given above have been investigated. In addition, agreement of tissue Doppler parameters obtained by TTE and TEE has also been studied (4, 5, 10-12). Nevertheless, most of these studies were carried out in patients under general anesthesia. Studies dealing with the agreement of conventional and tissue Doppler parameters obtained by TTE and TEE in outpatients or patients awake are quite rare (13).

In this issue of the Anatolian Journal of Cardiology, Aksakal et al. (14) carried out a cross-sectional study on outpatients about the agreement and interchangeability of conventional Doppler and myocardial deformation parameters obtained by TTE and TEE. Thirty-five patients were studied and TTE and then TEE was applied to all of them. Agreement and interchangeability of the conventional and tissue Doppler findings using both methods were studied using Bland-Altman analysis. The results showed that there were a good agreement for mitral inflow E

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and S, deceleration time, isovolumic relaxation and contraction times, myocardial performance index, ejection time, systolic and diastolic mitral annular pulse-wave velocities from TTE and TEE. These results were similar to previous ones. Nilsson et al. (10) carried out a study over 24 patients under general anesthesia and found that the systolic and diastolic mitral annular tissue Doppler velocities obtained by TTE and TEE were consistent. Furthermore, validity and importance of evaluation of both conventional and tissue Doppler parameters using perioperative TEE in the evaluation of diastolic functions were stressed (15).

In the present study, the agreement for left ventricular longitudinal peak systolic tissue velocities, peak systolic strain and peak systolic strain rate was found to be low. The authors speculated that the reason for the lack of agreement was due to the angle dependent nature of the technique as well as the limited spatial resolution and deformation analysis in one dimension. Based on these findings, the authors suggested that TTE and TEE could be used interchangeably in the assessment of LV diastolic indices by conventional echocardiographic methods, however could not be used interchangeably for assessment of LV segmental longitudinal systolic function.

Lack of a study in the literature that exactly matches to the present study makes it difficult to compare and interpret the findings. There is a partial overlapping between the findings of the present study and others, but those studies were carried out intraoperatively and in patients under general anesthesia. In their studies, MacLaren et al. (16) compared Doppler-based and non-Doppler (speckle tracking) strain, strain rate data in 304 myocardial segments obtained using TEE from 19 patients who underwent coronary artery bypass graft. Results showed that Doppler-based radial, but not longitudinal, cardiac motion appears to be the most feasible and reproducible technique of measuring myocardial velocity, strain, strain rate during cardiac surgery. The authors explained this by compromised image quality because of annular calcification and/or dropout in more than half of the longitudinal images and mitral annular calcification may obscure longitudinal imaging (16). The findings of that study (MacLaren's study) are in accordance with the present study in that reproducibility of longitudinal strain, strain rate was low. In addition, in their studies in which they compared right ventricular tissue Doppler imaging parameters in 24 patients under general anesthesia, Tousignant et al. (11) showed that right ventricular systolic annular velocities obtained by TTE and TEE are not correlated with Doppler-derived strain and strain rate.

However, there are some points that need to be addressed here: radial myocardial strain, strain parameters were not studied in present study. Another problem is that even if the diastolic left ventricular indices obtained by conventional and tissue velocities were compared, diastolic indices obtained by deformation parameters (strain rate) were not taken into account. Besides, in the Discussion section, data were not compared and discussed sufficiently with reference to the earlier studies in the literature.

At present, there is no study in literature supporting the poor agreement between left ventricular longitudinal strain and strain rate values obtained by TTE and TEE or the finding that these two methods could not be used interchangeably. On the contrary, a previous feasibility study revealed that TEE tissue velocity strain and strain rate measurements were in agreement with simultaneous TTE measurements and had clinical applicability. However, the data were acquired with success rates varying from 36 to 86% depending upon the segment (4). Again in another study, it was showed that transesophageal strain and strain rate measurements had clinical applicability and reproducibility. It was reported to be a sensitive means for detecting myocardial ischemia and to be superior to tissue velocity measurements since it can localize and define ischemic region (17). On the other hand, in a recent study conducted over 34 foramen ovale outpatients by Kurt et al. (13) it was found that both echocardiographic methods (TTE and TEE) were quite similar for 2-dimensional strain imaging, a non-Doppler deformation parameter, and that TEE 2D strain imaging (speckle tracking) measurements could be used preoperatively in the evaluation of ventricular functions.

In conclusion, TEE is a routinely and increasingly used valuable imaging technique employed in cardiac and non-cardiac surgery. In recent studies, usefulness of Doppler and non-Doppler parameters obtained by intraoperative TEE in the evaluation of regional and global systolic and diastolic myocardial functions and in the monitoring of hemodynamics has been well established. Although these measurements are conducted by computer- based automatic programs, relatively time consuming and off-line nature of these techniques could limit their routine use. It seems that larger scale investigations are needed into long- term prognostic value of conventional and tissue Doppler parameters obtained by intraoperative TEE.

Conflict of interest: None declared.

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References

1. Side CD, Gosling RG. Non-surgical assessment of cardiac function. Nature 1971; 232: 335-6. [CrossRef]
2. Silva F, Arruda R, Nobre A, Mendes M, Lemos A, Gallego J, et al. Impact of intraoperative transesophageal echocardiography in cardiac surgery: retrospective analysis of a series of 850 examinations. Rev Port Cardiol 2010; 29: 1363-82.
3. Carabello BA. Evolution of the study of left ventricular function: everything old is new again. Circulation 2002; 105: 2701-3. [CrossRef]
4. Simmons LA, Weidemann F, Sutherland GR, D'hooge J, Bijnens B, Sergeant P, et al. Doppler tissue velocity, strain, and strain rate imaging with transesophageal echocardiography in the operating room: a feasibility study. J Am Soc Echocardiogr 2002; 15: 768-76. [CrossRef]

5. Norrild K, Pedersen TF, Sloth E. Transesophageal tissue Doppler echocardiography for evaluation of myocardial function during aortic valve replacement. J Cardiothorac Vasc Anesth 2007; 21: 367-70. [CrossRef]
6. Imai H, Kurokawa S, Taneoka M, Baba H. Tissue Doppler imaging is useful for predicting the need for inotropic support after cardiac surgery. J Anesth 2011; 25: 805-11. [CrossRef]
7. D'hooge J, Heimdal A, Jamal F, Kukulski T, Bijnens B, Rademakers F, et al. Regional strain and strain rate measurements by cardiac ultrasound: principles, implementation and limitations. Eur J Echocardiogr 2000; 1: 154-70. [CrossRef]
8. Castro PL, Greenberg NL, Drinko J, Garcia MJ, Thomas JD. Potential pitfalls of strain rate imaging: angle dependency. Biomed Sci Instrum 2000; 36: 197-202.
9. Helle-Valle T, Crosby J, Edvardsen T, Lyseggen E, Amundsen BH, Smith HJ, et al. New noninvasive method for assessment of left ventricular rotation: speckle tracking echocardiography. Circulation 2005; 112: 3149-56. [CrossRef]
10. Nilsson B, Henningsson R, Brodin LA, Wandt B. Transesophageal echocardiographic acquisition of mitral annulus motion during monitoring of left ventricular function in anesthetized patients. J Am Soc Echocardiogr 2006; 19: 499-506. [CrossRef]
11. Tousignant CP, Bowry R, Levesque S, Denault AY. Regional differences in color tissue Doppler-derived measures of longitudinal right ventricular function using transesophageal and transthoracic echocardiography. J Cardiothorac Vasc Anesth 2008; 22: 400-5. [CrossRef]
12. Marcucci CE, Samad Z, Rivera J, Adams DB, Philips-Bute BG, Mahajan A, et al. A comparative evaluation of transesophageal and transthoracic echocardiography for measurement of left ventricular systolic strain using speckle tracking. J Cardiothorac Vasc Anesth 2012; 26: 17-25. [CrossRef]
13. Kurt M, Tanboğa IH, Işık T, Kaya A, Ekinci M, Bilen E, et al. Comparison of transthoracic and transesophageal 2-dimensional speckle tracking echocardiography. J Cardiothorac Vasc Anesth 2012; 26: 26-31. [CrossRef]
14. Aksakal E, Kaya A, Bakırcı EM, Kurt M, Tanboğa İH, Sevimli S, et al. Assessment of agreement between transthoracic and transesophageal echocardiography techniques in longitudinal deformation imaging and conventional Doppler parameters which are used estimation of left ventricular functions: a cross-sectional study. Anadolu Kardiyol Derg 2012; 12: 00-00.
15. Groban L, Dolinski SY. Transesophageal echocardiographic evaluation of diastolic function. Chest 2005; 128: 3652-63. [CrossRef]
16. MacLaren G, Kluger R, Connelly KA, Royse CF. Comparative feasibility of myocardial velocity and strain measurements using 2 different methods with transesophageal echocardiography during cardiac surgery. J Cardiothorac Vasc Anesth 2011; 25: 216-20. [CrossRef]
17. Skulstad H, Andersen K, Edvardsen T, Rein KA, Tonnessen TI, Hol PK, et al. Detection of ischemia and new insight into left ventricular physiology by strain Doppler and tissue velocity imaging: assessment during coronary bypass operation of the beating heart. J Am Soc Echocardiogr 2004; 17: 1225-33. [CrossRef]