JACC Vol. 27, No. 4
March 15, 1996:951–6

LETTERS TO THE EDITOR

Dimensionality of Flow Data

Use of "three dimensional" in the title of the report on flow patterns in the left ventricle by Kim et al. (1) raises an issue of terminology. "Three dimensional," as used in that title, denoted acquisition of three directional components of velocity and not, as readers may initially have assumed, data representing a three-dimensional volume.

As acquisition of anatomic and flow data becomes more comprehensive, either by magnetic resonance or by advanced ultrasound techniques, concise and unambiguous terminology relating to dimensionality becomes necessary. In accordance with echocardiographic usage, I would propose the following conventions: *Two dimensional* or *cross sectional* = acquisition in two *spatial* dimensions of a plane. *Three dimensional* = acquisition in all three *spatial* dimensions of a volume. *Cine* = acquisition of a temporal sequence of data sets. In echocardiography, "real-time" may be used, except when sequential images are reconstructed from data acquired over longer periods of time, when "cine" is more appropriate. *Two* or *three directional* = acquisition of two or three orthogonal components of velocity (2). Either may also be called multidirectional in that correlation of two or three components may reveal vectors in many directions.

According to this terminology, Kim et al. acquired two-dimensional, *three-directional* cine velocity data. For comprehensive investigation of flow in the heart, three-dimensional, three-directional cine acquisition would be required. To refer to this type of acquisition, "seven dimensional" has been used (3), but it is questionable whether measurement of a directional component of velocity is equivalent to determination of location in the dimensions of space–time. Flow velocity components are measured in relation to points or regions located in space–time, but the converse is not true.

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Reply

Kilner has raised an important issue of terminology in relation to dimensionality of flow data. He suggests that *three dimensional* be used for spacial dimensions or volumes only and should not be used to describe vectorial velocity data. He also suggests that these data be described as *two* or *three directional* instead. In our opinion there is no need for this distinction because "three dimensional" can be used for both spacial (volume) as well as vectorial data. For instance, in the report to which Kilner refers (1), the title contains the words "three-dimensional magnetic resonance velocity." In this case "three-dimensional" clearly refers to the nature of the velocity, not to its spacial variation. In a more recent report (2), the title "Three-dimensional reconstruction of the flow in a human left heart using magnetic resonance phase velocity encoding" is used. In this case, "three-dimensional" clearly refers to the spacial variation in the velocity, not to its vectorial nature. For decades, a velocity field has been referred to by its dimensionality. For instance, fully developed laminar flow in a pipe (Poiseuille flow) is one-dimensional flow. That is, the velocity varies in the radial direction only, not in the axial or circumferential directions. Flow in a curved tube by comparison is three dimensional because it varies in the radial, axial and circumferential directions. The important point is that these statements refer to the flow field, not to the nature in which the flow field (velocity) is measured. Therefore, even if the velocity vector is measured at a single point (e.g., by laser Doppler anemometry), the three-dimentional velocity is still obtained.

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Zatebradine and Exercise Tolerance

We read with interest the report by Frishman et al. (1) in a recent issue of the Journal. The authors concluded that sinus node inhibition with the bradycardic agent zatebradine does not provide sufficient antianginal and anti-ischemic effects to be useful for long-term treatment in patients with chronic angina who are taking nifedipine.

The authors offered two possible explanations for their findings: 1) The Bruce protocol used in the exercise might not be sufficiently sensitive to the reduction in cardiac ischemia expected to result from a decrease in heart rate of 12 to 14 beats/min. 2) The reduction in heart rate might offset an increase in other determinants of myocardial oxygen consumption, such as ventricular preload or myocardial contractility.

Myocardial ischemia is a result of an imbalance between myocardial oxygen supply and demand. Thus, in addition to factors determining myocardial oxygen demand, factors determining myocardial oxygen supply must also be taken into consideration. Heart rate is an important determinant, not only of myocardial oxygen demand, but also of myocardial oxygen supply. Kjekshus (2) in a meta-analysis of all prospective randomized studies of beta-blockade therapy in postmyocardial infarction patients, concluded that heart rate reduction after therapy was the best predictor of survival.

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0735-1097/96/$15.00
0735-1097(95)00530-7