Determination of Cardiac Output Across a Range of Values in Horses by M-Mode Echocardiography and Thermodilution

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(ABSTRACT)

Determinations of cardiac output (CO) by M-mode echocardiography were compared with simultaneous determinations by thermodilution in 2 conscious and 5 anesthetized horses. A range of cardiac outputs was induced by use of a pharmacological protocol (dopamine, 4 ug/kg/min, dobutamine, 4 ug/kg/min, and 10 ug/kg detomidine plus 20 ug/kg butorphanol, in sequence). Changes from baseline CO in response to each drug were evaluated, and data was analyzed to determine whether there were any interactions between drug treatment and measurement method. The mathematical relationship between CO as determined by M-mode echocardiography (CO_{echo}) and as determined by thermodilution (CO_{TD}) was described and used to predict CO_{TD} from CO_{echo}. The 2 methods were compared with respect to bias and variability in order to determine the suitability of CO_{echo} as a substitute for CO_{TD}. Sources of the variability for each method were determined.

Determination of CO by either method in standing horses was prohibitively difficult due to patient movement. The pharmacological protocol was satisfactory for inducing a range of cardiac outputs for the purpose of method comparison; however, use of dopamine did not offer any additional benefit over the use of dobutamine and was generally less reliable for increasing CO. Inclusion of detomidine provided an additional change in CO but did not increase the overall range of CO over that produced by halothane and dobutamine. CO_{echo} and CO_{TD} were significantly related by the predictive equation $CO_{TD} = (0.63 +/- 0.157) \times CO_{echo} + (16.6 +/- 3.22)$. The relatively large

standard errors associated with CO_{echo} measurements resulted in a broad 95% prediction interval such that CO_{echo} would have to change by more than 100% in order to be 95% confident that the determined value represents true hemodynamic change. CO_{echo} underestimated CO_{TD} by a mean of 10 +/- 6.3 l/min/450 kg. The large standard deviation of the bias resulted in broad limits of agreement (-22.3 to +2.3 l/min/450 kg). Measurement-to-measurement variability accounted for 28% of the total variation in CO_{TD} values and 64% of the total variation in CO_{echo} values. Results might be improved if the mean of 3-5 consecutive beats was used for each measurement, but as determined in this experiment, CO_{echo} is too variable to have confidence in its use for precise determinations of CO.