Calculation of spatial QRS, T, and Ventricular Gradient Vectors, and QRS-T angles

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Spatial peak QRS and T vectors

Spatial peak QRS and T vectors connect origin point with the furthest points away from the origin point in the QRS-loop and T-loop, respectively. Azimuth, elevation, and magnitude of spatial peak QRS and T vectors are calculated:

Spatial QRS vector:

$$t_R = \underset{t\,:\,t\,\in\,QRS}{\arg\max}\ \big(VM(t)\big);\quad \overrightarrow{QRSpeak} = \overrightarrow{VM}(t_R)$$

$$Spatial\ Peak\ QRS\ Azimuth = \arctan\left(\frac{QRSVz(t_R)dt}{QRSVx(t_R)dt}\right)$$

$$Spatial\ Peak\ QRS\ Elevation = \arctan\left(\frac{QRSVx(t_R)dt}{QRSVy(t_R)dt}\right)$$

$$Spatial\ Peak\ QRS\ Magnitude = \sqrt{QRSV_X^2 + QRSV_Y^2 + QRSV_Z^2}$$

Spatial T vector:

$$t_T = \underset{t\,:\,t\,\in\,T-wave}{\arg\max}\ \big(VM(t)\big)\ ;\ \overrightarrow{Tpeak} = \overrightarrow{VM}(t_T)$$

$$Spatial\ Peak\ T\ Azimuth = arctan\left(\frac{TVz(t_T)dt}{TVx(t_T)dt}\right)$$

$$Spatial\ Peak\ T\ Elevation = arctan\left(\frac{TVx(t_T)dt}{TVy(t_T)dt}\right)$$

$$Spatial\ Peak\ T\ Magnitude = \sqrt{TV_X^2 + TV_Y^2 + TV_Z^2}$$

Spatial area QRS and T vectors

Spatial area QRS and T vectors are calculated using equations, provided below.

Spatial area QRS vectors:

$$Spatial\ Area\ QRS\ Azimuth = \arctan\left(\frac{\int_{QRS-onset}^{QRS-offset} V_Z\,(t)dt}{\int_{QRS-onset}^{QRS-offset} V_X\,(t)dt}\right)$$

$$Spatial\ Area\ QRS\ Elevation = \arctan\left(\frac{\int_{QRS-onset}^{QRS-offset} V_X\,(t)dt}{\int_{QRS-onset}^{QRS-offset} V_Y\,(t)dt}\right)$$

$$Spatial\ QRS\ area =$$

$$= \sqrt{\left(\int_{QRS-onset}^{QRS-offset} V_x\,(t)dt\right)^2 + \left(\int_{QRS-onset}^{QRS-offset} V_y\,(t)dt\right)^2 + \left(\int_{QRS-onset}^{QRS-offset} V_Z\,(t)dt\right)^2}$$

Spatial area T vectors:

Azimuth, elevation, and magnitude of spatial area T vector were calculated:

$$\text{Spatial } Area\ T\ Azimuth = \arctan\left(\frac{\int_{QRS-offset}^{T-offset} V_Z(t)dt}{\int_{QRS-offset}^{T-offset} V_X(t)dt}\right)$$

$$Spatial\ Area\ T\ Elevation = \arctan\left(\frac{\int_{QRS-offset}^{T-offset} V_X\,(t)dt}{\int_{QRS-offset}^{T-offset} V_Y\,(t)dt}\right)$$

$$Spatial\ \ T\ area =$$

$$= \sqrt{\left(\int_{QRS-offset}^{T-offset} V_Z\,(t)dt\right)^2 + \left(\int_{QRS-offset}^{T-offset} V_Z\,(t)dt\right)^2 + \left(\int_{QRS-offset}^{T-offset} V_Z\,(t)dt\right)^2}$$

Spatial ventricular gradient (SVG) vectors:

Peak SVG vector:

$$\overrightarrow{SVGV} = \overrightarrow{QRSpeak} + \overrightarrow{Tpeak}$$

$$Spatial\ Peak\ SVG\ Azimuth = \arctan\left(\frac{SVGV_Z\ dt}{SVGV_X\ dt}\right)$$

$$Spatial\ Peak\ SVG\ Elevation = \arctan\left(\frac{SVGV_X\ dt}{SVGV_Y\ dt}\right)$$

$$Spatial\ Peak\ SVG\ Magnitude = \sqrt{{SVGV_Z}^2 + {SVGV_Z}^2 + {SVGV_Z}^2}$$

Wilson's (area) Spatial ventricular gradient (SVG):

$$Spatial\ Area\ SVG\ Azimuth = \arctan\left(\frac{\int_{QRS-onset}^{T-offset} V_Z\,(t)dt}{\int_{QRS-onset}^{T-offset} V_X\,(t)dt}\right)$$

$$Spatial\ Area\ SVG\ Elevation = \arctan\left(\frac{\int_{QRS-onset}^{T-offset} V_X\,(t)dt}{\int_{QRS-onset}^{T-offset} V_Y\,(t)dt}\right)$$

$$|SVG| = \sqrt{\left(\int_{QBeg}^{TEnd} V_x(t)\,dt\right)^2 + \left(\int_{QBeg}^{TEnd} V_y(t)\,dt\right)^2 + \left(\int_{QBeg}^{TEnd} V_z(t)dt\right)^2}$$

Spatial QRS-T angles:

Spatial Peak QRS-T angle

Spatial peak QRS-T angle is calculated as the 3-dimensional angle between the spatial peak QRS vector and the spatial peak T vector:

$$Spatial\ peak\ QRS - T\ angle = \arccos\left(\frac{\overrightarrow{QRSpeak} \cdot \overrightarrow{Tpeak}}{|QRSpeak||Tpeak|}\right)$$

Spatial Area (or Mean) QRS-T angle:

Spatial area QRS-T angle is calculated as the 3-dimensional angle between the spatial area QRS vector and the spatial area T vector:

$$Spatial\ area\ QRS - T\ angle = \arccos\left(\frac{\overrightarrow{QRSmean} \cdot \overrightarrow{Tmean}}{|QRSmean||Tmean|}\right)$$