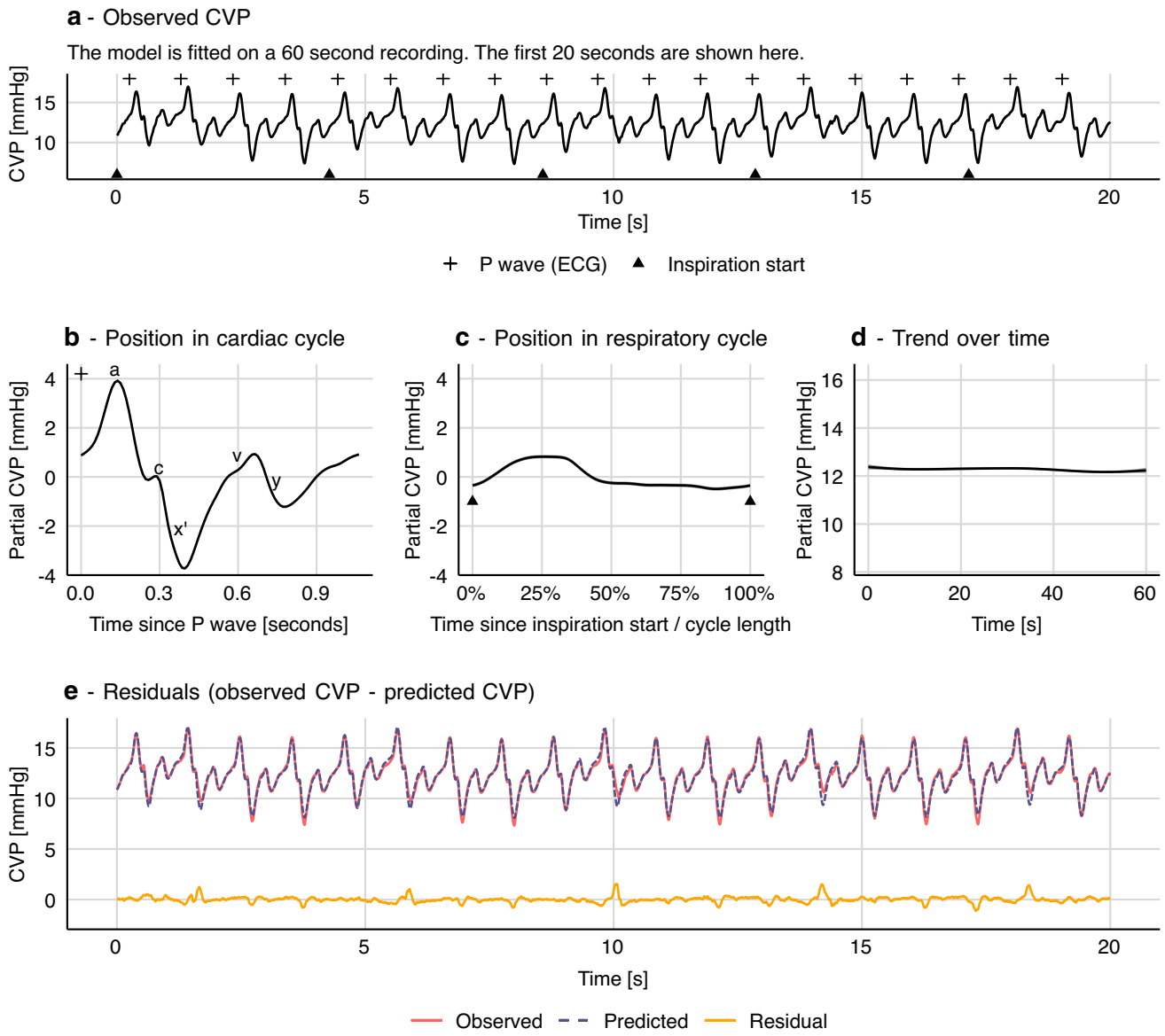

Fig. 4 Generalized additive model of central venous pressure (CVP). Variation in CVP is explained by the effects of the cardiac cycle and the respiratory cycle. In this model there is no interaction between the two effects. Grey shades in **b**, **c** and **d** represent 95% confidence intervals (often too narrow to be visible)

influence CVP and can change over longer periods. These include, but are not limited to: surgical activity, autonomic regulation and medication.

In this example, we model the entire waveform; not just a time series of derived measurements as in the above example with pulse pressure. The unit observations are individual samples of a 125 Hz CVP recording. Each sample has a value (CVP) and a time. Using this sample time, the timing of P waves from the ECG and the timing of each inspiration start, we can compute two additional features: the sample's position in the cardiac cycle (time since the latest P wave) and its position in the respiratory cycle (similar to example 1). Timing of P waves was calculated by subtracting a constant, manually measured, PR interval from algorithmically determined QRS complex timings. The exact length of the subtracted interval is not very important. It simply ensures that the atrial contraction is placed in the beginning of a cardiac cycle rather than in the end of the previous cycle. We model the effect of the cardiac cycle with a non-cyclic spline, since cardiac cycles vary slightly in length (due to respiratory sinus arrhythmia).

A first approach to modelling CVP from these three features could be a simple extension of the PP model proposed in example 1: