Predictive Modeling of PCA Effect on Postoperative Pain Management

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OBJECTIVES: Our study aims to develop predictive models of the time course of postoperative pain, nausea, and vomiting under patient controlled analgesia (PCA) treatment.

METHODS: Serial postoperative visual analogue scale (VAS) pain scores, severity of nausea scale (N) ranging from 1 to 10, and vomiting frequency (V) of 28,656 patients were retrospectively collected given PCA treatment with fentanyl and additional medications of keromin, tridol, and pethidine given as needed. VAS was modeled as a logistic function of a latent variable F that denotes the underlying pain intensity associated with pain nerve firing frequency. F was described as a turnover model with turnover rate inhibited by fentanyl plasma exposure E, which was described as a KPD model because drug concentration data was not available. N was described as a function of E using a logistic model, and V was modeled as a function of VAS and N using a Poisson distribution. N was assumed to have threshold value NTHR.

RESULTS: Mixture model identified two populations with distinct pain profiles (Fig. 1A). Turnover rate of F was higher in females (p<0.05) and increasing age (p<0.0001). Cancer surgery (p<0.0001) and general anesthesia (p<0.0001) were associated with higher baseline pain score. NTHR was lower in females (p<0.0001). Tramadol (p<0.0001), ketorolac (p<0.0001), and pethidine (p<0.0001) contributed to lower NTHR. In addition to N, VAS significantly increased V (p<0.0001). The time courses of predicted probability of N and V well describe those of observed probability (Fig. 1B).

CONCLUSION: Our model successfully predicted the time courses of VAS, N, and V under PCA infusion. The developed model would be useful in devising individualized PCA regimens under widely different situations to optimize pain and side effects management.

(A)
Figure 1. Goodness of fit plots of (A) pain score, stratified by subpopulations with outermost bands encompassing 95% of the observations, and (B) nausea and vomiting. (RED: smoothed observation, BLUE: smoothed prediction)