SUPPLEMENTARY MATERIAL

Simplified solution for general parametric criterion 1:

The general parametric criterion 1 can be divided into a pair of equations:

$$\left(\frac{R_{int}\#_{cell}}{Q_B \emptyset_t \sum_i \frac{\emptyset_t^i C_t^i}{K_p^i/B:P}}\right)_{Chip} = \left(\frac{R_{int}\#_{cell}}{Q_B \emptyset_t \sum_i \frac{\emptyset_t^i C_t^i}{K_p^i/B:P}}\right)_{Hum} \quad \text{(Eqn. 7)}$$

and

$$\left(\frac{\sum_i \frac{\emptyset_t^i C_t^i}{K_p^i/B:P}}{K_p/B:P}\right)_{Chip} = \left(\frac{\sum_i \frac{\emptyset_t^i C_t^i}{K_p^i/B:P}}{K_p/B:P}\right)_{Hum} \quad \text{(Eqn. 8)}$$

The Eqn. 8 is satisfied when the cardiac output ratios and partitioning coefficients for each organ on the chip are set to be equal to those of the human body:

$$\emptyset_t^{Chip} = \emptyset_t^{Hum} \text{ and } \frac{K_p^{Chip}}{B:P^{Chip}} = \frac{K_p^{Hum}}{B:P^{Hum}}$$

Then the Eqn. 7 can be transformed into the form below as listed in Table 2:

$$\frac{Q_B^{Chip}}{R_{int}^{Chip}\#_{cell}^{Chip}} = \frac{Q_B^{Hum}}{R_{int}^{Hum}\#_{cell}^{Hum}}$$

Derivation of general parametric criteria 2 and 3:

The time-dependent mass balance equations, Eqn. 2 and Eqn. 3, for tissue and blood compartments, respectively, can also be used to derive the general parametric criteria 2 and 3. The Eqn. 2 and 3 are represented in terms of blood residence time in tissue (τ_t) and blood compartment (τ_B) as below:

$$\frac{dC_{blood}}{dt} = \frac{\sum_i \frac{\emptyset_t^i C_t^i}{K_p^i/B:P} - C_{blood}}{\tau_B} \quad \text{(Eqn. 9)}$$

$$\frac{dC_t}{dt} = \frac{C_{blood}^{in} - \dfrac{C_t}{K_p/B{:}P}}{\tau_t} - \frac{R_{int}\#_{cell}C_t}{\tau_t Q_B \emptyset_t} \qquad \text{(Eqn. 10)}$$

Then the criteria 2 and 3 can be written in a parametric form as below:

General Parametric Criterion 2: *(for each organ)*

$$\left(\frac{\sum_i \dfrac{\emptyset_t^i C_t^i}{K_p^i/B{:}P} - 1}{\tau_B}\right)_{Chip} = \left(\frac{\sum_i \dfrac{\emptyset_t^i C_t^i}{K_p^i/B{:}P} - 1}{\tau_B}\right)_{Hum} \qquad \text{(Eqn. 11)}$$

General Parametric Criterion 3: *(for each organ)*

$$\left(\frac{f_{t,u}\,K_p/B{:}P - 1}{\tau_t\,K_p/B{:}P} - \frac{f_{t,u}R_{int}\#_{cell}}{\tau_t Q_B \emptyset_t}\right)_{Chip} = \left(\frac{f_{t,u}K_p/B{:}P - 1}{\tau_t\,K_p/B{:}P} - \frac{f_{t,u}R_{int}\#_{cell}}{\tau_t Q_B \emptyset_t}\right)_{Hum} \qquad \text{(Eqn. 12)}$$

One simple solution to these equations is setting the residence time for each organ on the chip equal to the residence times in the human body in addition to the previously set parameters to satisfy criterion 1. Therefore, only additional criteria added in Table 1 for µHuman-on-chip system are

$$\tau_t^{Chip} = \tau_t^{Hum}$$

and

$$\tau_B^{Chip} = \tau_B^{Hum}$$