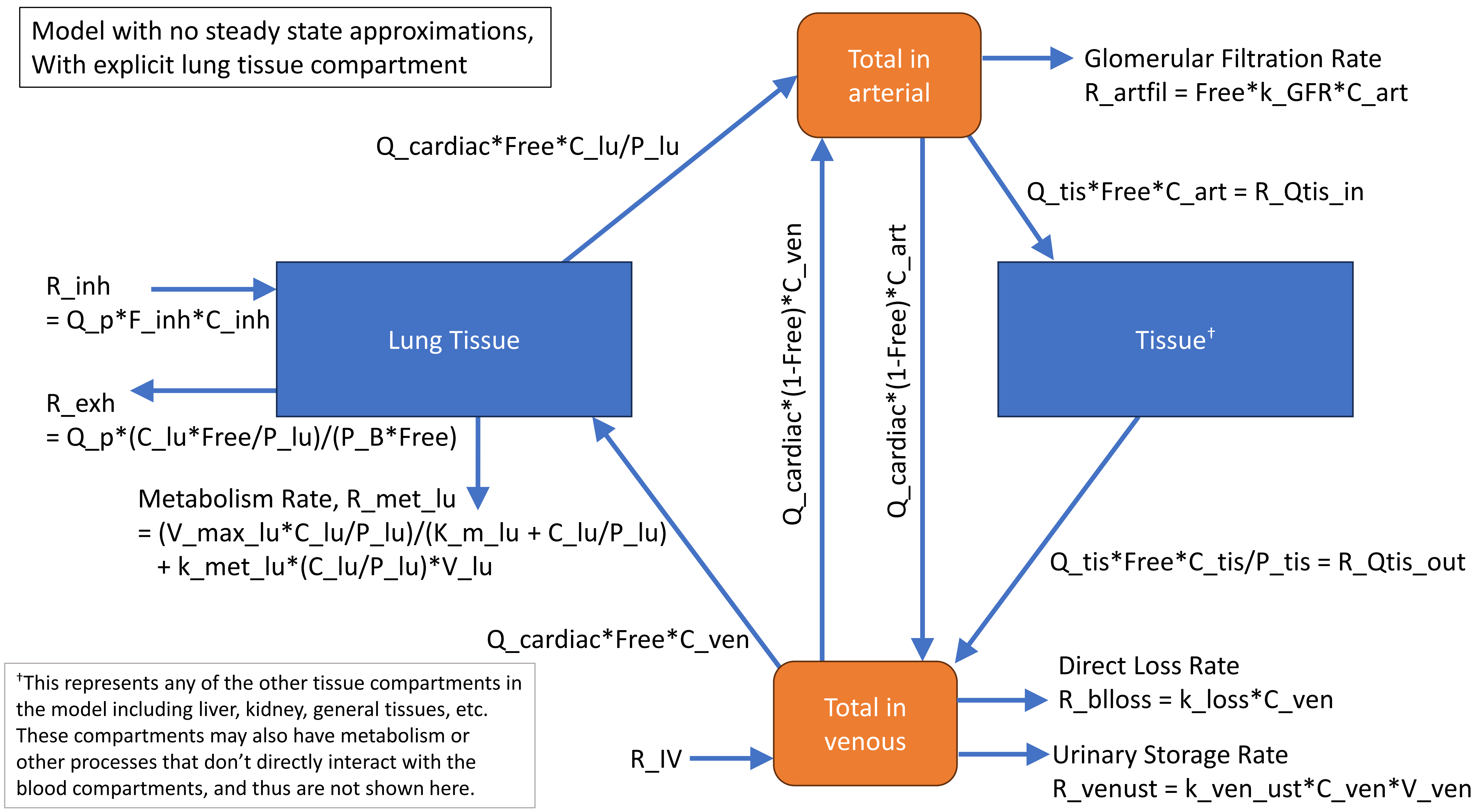

Model with no steady state approximations,
With explicit lung tissue compartment
Total in arterial
Glomerular Filtration Rate
R_artfil = Free*k_GFR*C_art
Q_cardiac*Free*C_lu/P_lu
Q_tis*Free*C_art = R_Qtis_in
R_inh
= Q_p*F_inh*C_inh
Lung Tissue
Q_cardiac*(1-Free)*C_ven
Q_cardiac*(1-Free)*C_art
Tissue†
R_exh
= Q_p*(C_lu*Free/P_lu)/(P_B*Free)
Metabolism Rate, R_met_lu
= (V_max_lu*C_lu/P_lu)/(K_m_lu + C_lu/P_lu)
+ k_met_lu*(C_lu/P_lu)*V_lu
Q_tis*Free*C_tis/P_tis = R_Qtis_out
Q_cardiac*Free*C_ven
†This represents any of the other tissue compartments in the model including liver, kidney, general tissues, etc. These compartments may also have metabolism or other processes that don't directly interact with the blood compartments, and thus are not shown here.
Direct Loss Rate
R_blloss = k_loss*C_ven
Total in venous
R_IV
Urinary Storage Rate
R_venust = k_ven_ust*C_ven*V_ven

Model with **no** steady state approximations
venous_ss = 0, arterial_ss = 0, GE_ss = 0, exist_lung = 1

R_loss = k_ven_ust*C_ven*V_ven + k_loss*C_ven
R_artfil = Free*k_GFR*C_art

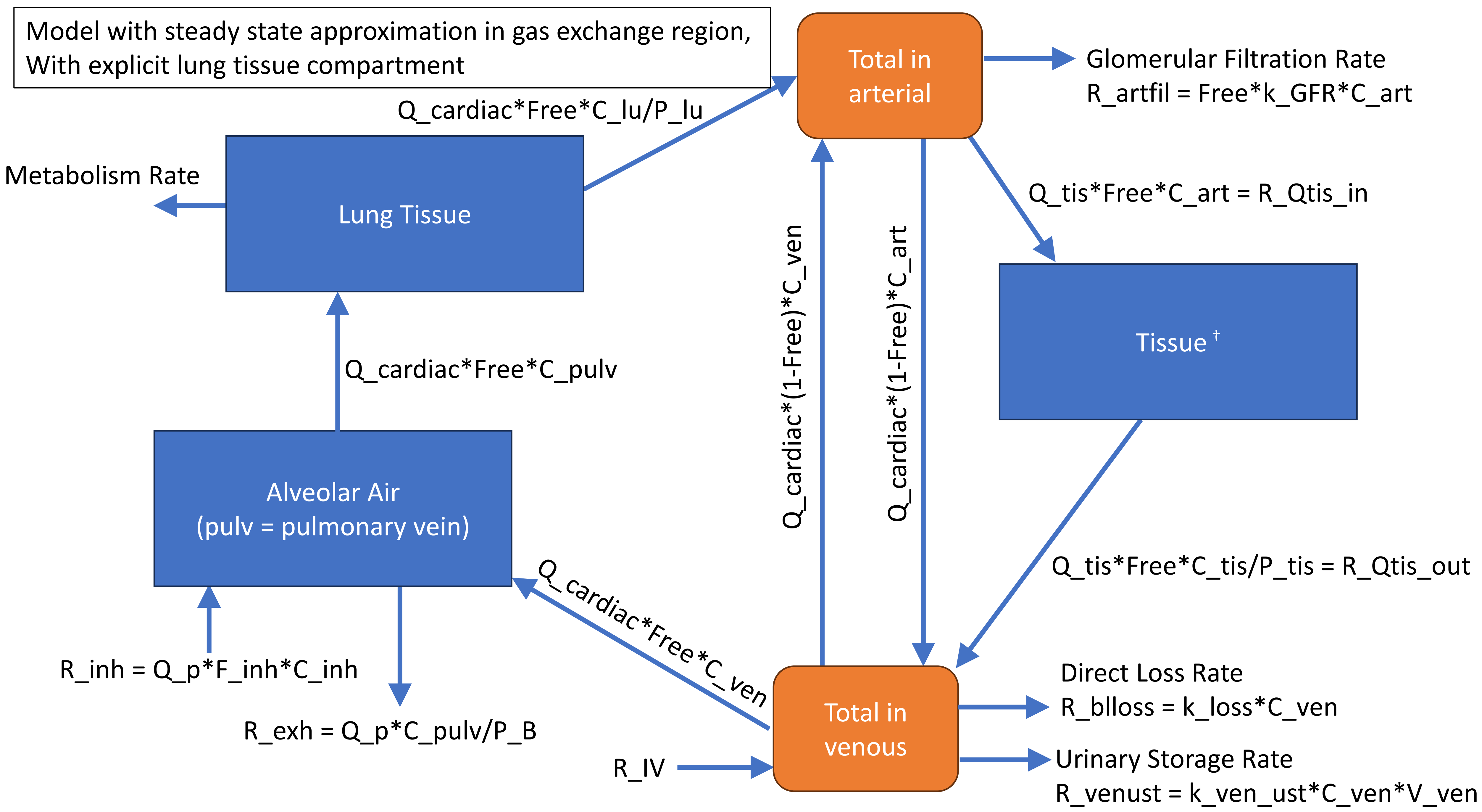
dt(A_tis) = R_Qtis_in – R_Qtis_out

dt(A_ven) = R_Qtis_out + R_IV + Q_cardiac*(1-Free)*C_art
– Q_cardiac*Free*C_ven – Q_cardiac*(1-Free)*C_ven – R_loss
= R_Qtis_out + R_IV + Q_cardiac*(1-Free)*C_art – Q_cardiac*C_ven – R_loss

dt(A_lu) = R_inh – R_exh + Q_cardiac*Free*C_ven – Q_cardiac*Free*C_lu/P_lu – R_met_lu
= Q_p*F_inh*C_inh – Q_p*(C_lu/P_lu)/P_B + Q_cardiac*Free*(C_ven – C_lu/P_lu) – R_met_lu

At steady state with no metabolism,
C_lu/P_lu = (Q_cardiac*Free*C_ven + Q_p*F_inh*C_inh) / (Q_cardiac*Free + Q_p/P_B)

dt(A_art) = Q_cardiac*Free*C_lu/P_lu + Q_cardiac*(1-Free)*C_ven
– R_Qtis_in – Q_cardiac*(1-Free)*C_art – R_artfil


Model with steady state approximation in gas exchange region,
With explicit lung tissue compartment
Total in arterial
Glomerular Filtration Rate
R_artfil = Free*k_GFR*C_art
Q_cardiac*Free*C_lu/P_lu
Metabolism Rate
Lung Tissue
Q_tis*Free*C_art = R_Qtis_in
Q_cardiac*(1-Free)*C_ven
Q_cardiac*(1-Free)*C_art
Tissue †
Q_cardiac*Free*C_pulv
Alveolar Air
(pulv = pulmonary vein)
Q_tis*Free*C_tis/P_tis = R_Qtis_out
Q_cardiac*Free*C_ven
R_inh = Q_p*F_inh*C_inh
Direct Loss Rate
R_blloss = k_loss*C_ven
Total in venous
R_exh = Q_p*C_pulv/P_B
R_IV
Urinary Storage Rate
R_venust = k_ven_ust*C_ven*V_ven

Model with steady state approximation in gas exchange region,
With explicit lung tissue compartment
venous_ss = 0, arterial_ss = 0, GE_ss = 1, exist_lung = 1

R_loss = k_ven_ust*C_ven*V_ven + k_loss*C_ven
R_artfil = Free*k_GFR*C_art

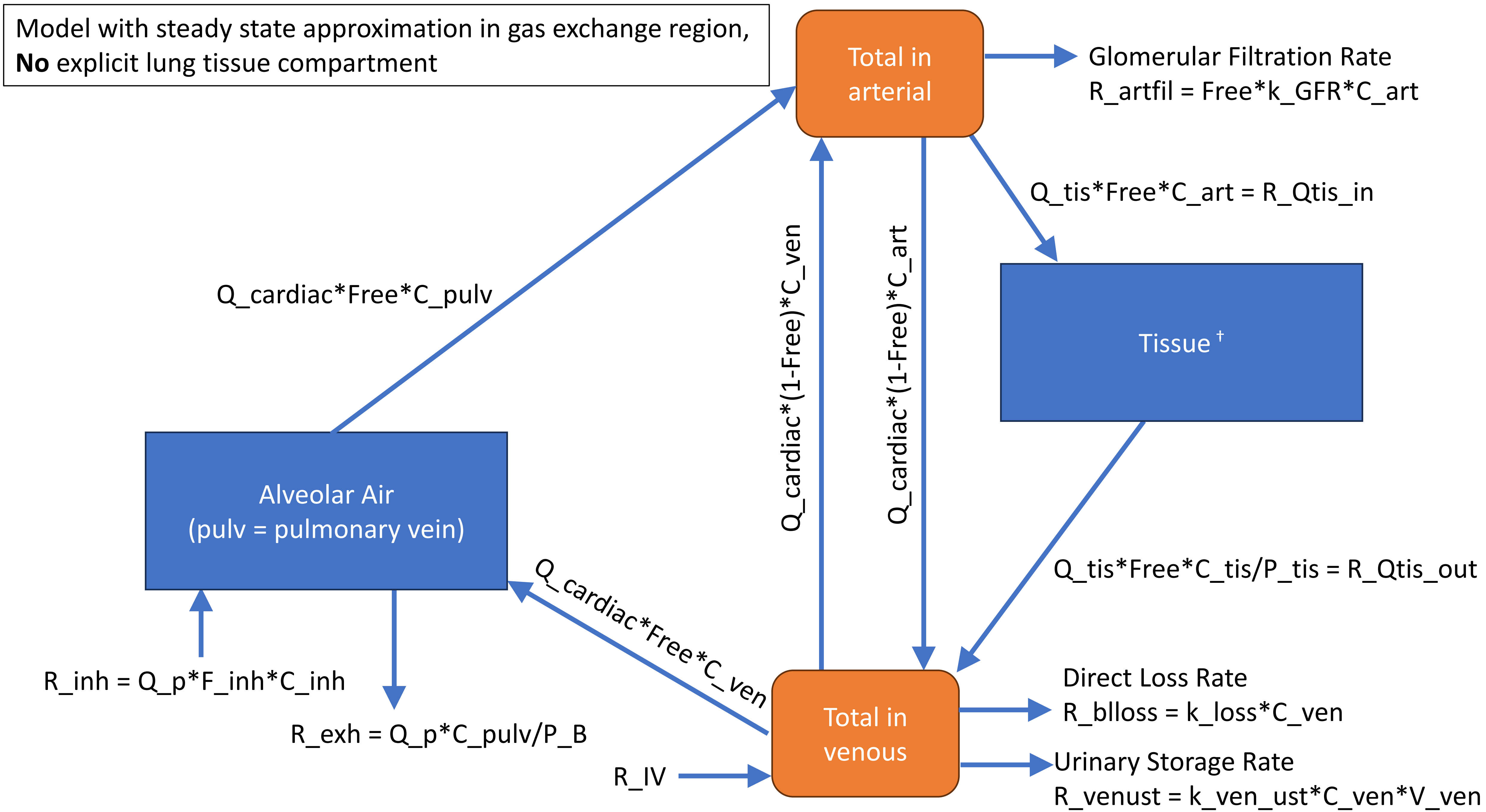
dt(A_tis) = R_Qtis_in – R_Qtis_out

dt(A_ven) = R_Qtis_out + R_IV + Q_cardiac*(1-Free)*C_art
– Q_cardiac*Free*C_ven – Q_cardiac*(1-Free)*C_ven – R_loss
= R_Qtis_out + R_IV + Q_cardiac*(1-Free)*C_art – Q_cardiac*C_ven – R_loss

Dt(A_pulv) = Q_cardiac*Free*C_ven + R_inh – Q_cardiac*Free*C_pulv – R_exh
= Q_cardiac*Free*C_ven + Q_p*F_inh*C_inh – Q_cardiac*Free*C_pulv – Q_p*C_pulv/P_B
Set equal to zero and solve for C_pulv,
C_pulv = (Q_cardiac*Free*C_ven + Q_p*F_inh*C_inh) / (Q_cardiac*Free + Q_p/P_B)

dt(A_lu) = Q_cardiac*Free*C_pulv – Q_cardiac*Free*C_lu/P_lu – R_met_lu

dt(A_art) = Q_cardiac*Free*C_lu/P_lu + Q_cardiac*(1-Free)*C_ven
– R_Qtis_in – Q_cardiac*(1-Free)*C_art – R_artfil


Model with steady state approximation in gas exchange region,
No explicit lung tissue compartment
Total in arterial
Glomerular Filtration Rate
R_artfil = Free*k_GFR*C_art
Q_tis*Free*C_art = R_Qtis_in
Q_cardiac*Free*C_pulv
Q_cardiac*(1-Free)*C_ven
Q_cardiac*(1-Free)*C_art
Tissue †
Alveolar Air
(pulv = pulmonary vein)
Q_cardiac*Free*C_ven
Q_tis*Free*C_tis/P_tis = R_Qtis_out
R_inh = Q_p*F_inh*C_inh
R_exh = Q_p*C_pulv/P_B
R_IV
Total in venous
Direct Loss Rate
R_blloss = k_loss*C_ven
Urinary Storage Rate
R_venust = k_ven_ust*C_ven*V_ven

Model with steady state approximation in gas exchange region,
No explicit lung tissue compartment
venous_ss = 0, arterial_ss = 0, GE_ss = 1, exist_lung = 0

R_loss = k_ven_ust*C_ven*V_ven + k_loss*C_ven
R_artfil = Free*k_GFR*C_art

dt(A_tis) = R_Qtis_in – R_Qtis_out

dt(A_ven) = R_Qtis_out + R_IV + Q_cardiac*(1-Free)*C_art
– Q_cardiac*Free*C_ven – Q_cardiac*(1-Free)*C_ven – R_loss
= R_Qtis_out + R_IV + Q_cardiac*(1-Free)*C_art – Q_cardiac*C_ven – R_loss

Dt(A_pulv) = Q_cardiac*Free*C_ven + R_inh – Q_cardiac*Free*C_pulv – R_exh
set equal to zero and solve for C_pulv
C_pulv = (Q_cardiac*Free*C_ven + Q_p*F_inh*C_inh) / (Q_cardiac*Free + Q_p/P_B)

dt(A_art) = Q_cardiac*Free*C_pulv + Q_cardiac*(1-Free)*C_ven – R_Qtis_in – Q_cardiac*(1-Free)*C_art – R_artfil
= Q_cardiac*Free*C_lu/P_lu + Q_cardiac*(1-Free)*C_ven – Q_cardiac*C_art – R_artfil

Implementing the steady state approximations for blood compartments (venous_ss = 1, arterial_ss = 1)…

dt(A_ven) = R_Qtis_out + R_IV + Q_cardiac*(1-Free)*C_art – Q_cardiac*C_ven – R_loss
= R_Qtis_out + R_IV + Q_cardiac*(1-Free)*C_art
– Q_cardiac*C_ven – k_ven_ust*V_ven*C_ven – k_loss*C_ven
Steady state approx.:
C_ven = (R_Qtis_out + Q_cardiac*(1-Free)*C_art +R_IV)/(Q_cardiac + k_ven_ust*V_ven + k_loss)

C_pulv = (Q_cardiac*Free*C_ven + Q_p*F_inh*C_inh) / (Q_cardiac*Free + Q_p/P_B)

With explicit lung tissue:
dt(A_art) = Q_cardiac*Free*C_lu/P_lu + Q_cardiac*(1-Free)*C_ven – Q_cardiac*C_art – R_artfil
= Q_cardiac*Free*C_lu/P_lu + Q_cardiac*(1-Free)*C_ven – Q_cardiac*C_art – Free*k_GFR*C_art
Steady state approx.:
C_art = (Q_cardiac*Free*C_lu/P_lu + Q_cardiac*(1-Free)*C_ven)/(Q_cardiac + Free*k_GFR)

With no explicit lung tissue:
dt(A_art) = Q_cardiac*Free*C_pulv + Q_cardiac*(1-Free)*C_ven – Q_cardiac*C_art – R_artfil
= Q_cardiac*Free*C_pulv + Q_cardiac*(1-Free)*C_ven – Q_cardiac*C_art – Free*k_GFR*C_art
Steady state approx.:
C_art = (Q_cardiac*Free*C_pulv + Q_cardiac*(1-Free)*C_ven)/(Q_cardiac + Free*k_GFR)

Implementing the steady state approximations for blood compartments (venous_ss = 1, arterial_ss = 1)…

With explicit lung tissue and no approx. in gas exchange region (GE_ss = 0, exist_lung = 1):

C_ven = (R_Qtis_out + Q_cardiac*(1-Free)*C_art +R_IV)/(Q_cardiac + k_ven_ust*V_ven + k_loss)

C_pulv = 0

C_art = (Q_cardiac*Free*C_lu/P_lu + Q_cardiac*(1-Free)*C_ven)/(Q_cardiac + Free*k_GFR)

Matrix form:

$$\begin{bmatrix} \text{Q\_cardiac} + \text{k\_ven\_ust} * \text{V\_ven} + \text{k\_loss} & -\text{Q\_cardiac}(1 - \text{Free}) \\ -\text{Q\_cardiac}(1 - \text{Free}) & \text{Q\_cardiac} + \text{Free} * \text{k\_GFR} \end{bmatrix} \begin{bmatrix} \text{C\_ven} \\ \text{C\_art} \end{bmatrix} = \begin{bmatrix} \text{R\_IV} + \text{R\_Qtis\_out} \\ \text{Q\_cardiac} * \text{Free} * \text{C\_lu/P\_lu} \end{bmatrix}$$

With explicit lung tissue and steady state approx. in gas exchange region (GE_ss = 1, exist_lung = 1):

C_ven = (R_Qtis_out + Q_cardiac*(1-Free)*C_art +R_IV)/(Q_cardiac + k_ven_ust*V_ven + k_loss)

C_pulv = (Q_cardiac*Free*C_ven + Q_p*F_inh*C_inh) / (Q_cardiac*Free + Q_p/P_B)

C_art = (Q_cardiac*Free*C_lu/P_lu + Q_cardiac*(1-Free)*C_ven)/(Q_cardiac + Free*k_GFR)

Matrix form:

$$\begin{bmatrix} \text{Q\_cardiac} + \text{k\_ven\_ust} * \text{V\_ven} + \text{k\_loss} & 0 & -\text{Q\_cardiac}(1 - \text{Free}) \\ -\text{Q\_cardiac} * \text{Free} & \text{Q\_cardiac} * \text{Free} + \text{Q\_p/P\_B} & 0 \\ -\text{Q\_cardiac}(1 - \text{Free}) & 0 & \text{Q\_cardiac} + \text{Free} * \text{k\_GFR} \end{bmatrix} \begin{bmatrix} \text{C\_ven} \\ \text{C\_pulv} \\ \text{C\_art} \end{bmatrix} = \begin{bmatrix} \text{R\_IV} + \text{R\_Qtis\_out} \\ \text{Q\_p} * \text{F\_inh} * \text{C\_inh} \\ \text{Q\_cardiac} * \text{Free} * \text{C\_lu/P\_lu} \end{bmatrix}$$

Implementing the steady state approximations for blood compartments (venous_ss = 1, arterial_ss = 1)…

Without explicit lung tissue and with steady state approx. in gas exchange region (GE_ss = 1, exist_lung = 0):

C_ven = (R_Qtis_out + Q_cardiac*(1-Free)*C_art +R_IV)/(Q_cardiac + k_ven_ust*V_ven + k_loss)

C_pulv = (Q_cardiac*Free*C_ven + Q_p*F_inh*C_inh) / (Q_cardiac*Free + Q_p/P_B)

C_art = (Q_cardiac*Free*C_pulv + Q_cardiac*(1-Free)*C_ven)/(Q_cardiac + Free*k_GFR)

Matrix form:

$$\begin{bmatrix} \text{Q\_cardiac} + \text{k\_ven\_ust} * \text{V\_ven} + \text{k\_loss} & 0 & -\text{Q\_cardiac}(1-\text{Free}) \\ -\text{Q\_cardiac} * \text{Free} & \text{Q\_cardiac} * \text{Free} + \text{Q\_p}/\text{P\_B} & 0 \\ -\text{Q\_cardiac}(1-\text{Free}) & -\text{Q\_cardiac} * \text{Free} & \text{Q\_cardiac} + \text{Free} * \text{k\_GFR} \end{bmatrix} \begin{bmatrix} \text{C\_ven} \\ \text{C\_pulv} \\ \text{C\_art} \end{bmatrix} = \begin{bmatrix} \text{R\_IV} + \text{R\_Qtis\_out} \\ \text{Q\_p} * \text{F\_inh} * \text{C\_inh} \\ 0 \end{bmatrix}$$

To solve the matrix equations describing each case, we used YACAS (a symbolic algebra tool) online:
https://www.yacas.org/yacas_online/yacas_online.html

Relevant Documentation:

SolveMatrix function used to solve the matrix equation

https://yacas.readthedocs.io/en/latest/reference_manual/linear-algebra.html#SolveMatrix

CForm function used to convert to solution to C code

https://yacas.readthedocs.io/en/latest/reference_manual/io.html#CForm

Parameter names were simplified for use with YACAS as follows:

Name in Template Code	Name Used as Input to YACAS
Q_cardiac	Qc
Free	F
k_GFR	kG
C_lu	Clu
P_lu	Plu

Name in Template Code	Name Used as Input to YACAS
Q_p	Qp
P_B	PB
R_IV + R_Qtis_out	R
k_ven_ust*V_ven + k_loss	L
Q_p*F_inh*C_inh	Qin

Implementing the steady state approximations for blood compartments,

with explicit lung tissue and no approx. in the gas exchange region

Using YACAS (symbolic algebra tool) online: https://www.yacas.org/yacas_online/yacas_online.html

Relevant Documentation:

https://yacas.readthedocs.io/en/latest/reference_manual/linear-algebra.html#SolveMatrix

https://yacas.readthedocs.io/en/latest/reference_manual/io.html#CForm

```
M:={{Qc+L,-Qc*(1-F)},{-Qc*(1-F),Qc+F*kG}}
x:={{Cv},{Ca}}
b:={{R},{Qc*F*Clu/Plu}}
x := SolveMatrix(M, b)
```

R = R_IV + R_Qtis_out L = k_ven_ust∗V_ven + k_loss

```
CForm(x[1])
    C_ven = ( (Qc+F∗kG)∗R+(Qc∗(1−F)∗Qc∗F∗Clu)/Plu ) / ( (Qc+L)∗(Qc+F∗kG)−pow(Qc∗(1−F),2) )
CForm(x[2])
    C_art = ( ((Qc+L)∗Qc∗F∗Clu)/Plu+Qc∗(1−F)∗R ) / ( (Qc+L)∗(Qc+F∗kG)−pow(Qc∗(1−F),2) )
If F=1, kG=0, L=0:
C_ven = ( (Qc+1*0)∗R+(Qc∗(1−1)∗Qc∗1∗Clu)/Plu ) / ( (Qc+0)∗(Qc+1∗0)−pow(Qc∗(1−1),2) )
      = ( (Qc)∗R ) / ( (Qc)∗(Qc) ) = R/Qc
C_art = ( ((Qc+0)∗Qc∗1∗Clu)/Plu+Qc∗(1−1)∗R ) / ( (Qc+0)∗(Qc+1∗0)−pow(Qc∗(1−1),2) )
      = ( ((Qc)∗Qc∗Clu)/Plu ) / ( (Qc)∗(Qc) ) = Clu/Plu
```

Implementing the steady state approximations for blood compartments,

with explicit lung tissue and steady state approx. in the gas exchange region

Using YACAS (symbolic algebra tool) online: https://www.yacas.org/yacas_online/yacas_online.html

Relevant Documentation:

https://yacas.readthedocs.io/en/latest/reference_manual/linear-algebra.html#SolveMatrix

https://yacas.readthedocs.io/en/latest/reference_manual/io.html#CForm

```
M:={{Qc+L,0,-Qc*(1-F)},{-Qc*F,Qc*F+Qp/PB,0},{-Qc*(1-F),0,Qc+F*kG}}
x:={{Cv},{Cp},{Ca}}
b:={{R},{Qin},{Qc*F*Clu/Plu}}
x := SolveMatrix(M, b)
```

```
R = R_IV + R_Qtis_out
Qin = Q_p*F_inh*C_inh
L = k_ven_ust∗V_ven + k_loss
```

```
CForm(x[1])
( (Qc+F∗kG)∗(Qc∗F+Qp/PB)∗R+(Qc∗(1−F)∗(Qc∗F+Qp/PB)∗Qc∗F∗Clu)/Plu ) /
        ( (Qc+L)∗(Qc∗F+Qp/PB)∗(Qc+F∗kG)−(Qc∗F+Qp/PB)∗pow(Qc∗(1−F),2) )
CForm(x[2])
( (Qc+F∗kG)∗(Qc+L)∗Qin+(Qc∗(1−F)∗Qc∗F∗Qc∗F∗Clu)/Plu+(Qc+F∗kG)∗Qc∗F∗R−Qin∗pow(Qc∗(1−F),2) ) /
        ( (Qc+L)∗(Qc∗F+Qp/PB)∗(Qc+F∗kG)−(Qc∗F+Qp/PB)∗pow(Qc∗(1−F),2) )
CForm(x[3])
( ((Qc+L)∗(Qc∗F+Qp/PB)∗Qc∗F∗Clu)/Plu+Qc∗(1−F)∗(Qc∗F+Qp/PB)∗R ) /
        ( (Qc+L)∗(Qc∗F+Qp/PB)∗(Qc+F∗kG)−(Qc∗F+Qp/PB)∗pow(Qc∗(1−F),2) )
```

R = R_IV + R_Qtis_out
Qin = Q_p*F_inh*C_inh
L = k_ven_ust∗V_ven + k_loss

Implementing the steady state approximations for blood compartments,

with explicit lung tissue and steady state approx. in the gas exchange region

From previous:

$$Cven = \frac{(Qc+F*kG)*(Qc*F+Qp/PB)*R+(Qc*(1-F)*(Qc*F+Qp/PB)*Qc*F*Clu)/Plu}{(Qc+L)*(Qc*F+Qp/PB)*(Qc+F*kG)-(Qc*F+Qp/PB)*pow(Qc*(1-F),2)}$$

$$Cpulv = \frac{(Qc+F*kG)*(Qc+L)*Qin+(Qc*(1-F)*Qc*F*Qc*F*Clu)/Plu+(Qc+F*kG)*Qc*F*R-Qin*pow(Qc*(1-F),2)}{(Qc+L)*(Qc*F+Qp/PB)*(Qc+F*kG)-(Qc*F+Qp/PB)*pow(Qc*(1-F),2)}$$

$$Cart = \frac{((Qc+L)*(Qc*F+Qp/PB)*Qc*F*Clu)/Plu+Qc*(1-F)*(Qc*F+Qp/PB)*R}{(Qc+L)*(Qc*F+Qp/PB)*(Qc+F*kG)-(Qc*F+Qp/PB)*pow(Qc*(1-F),2)}$$

If F=1, kG=0, L=0:

$$Cven = \frac{(Qc+1*0)*(Qc*1+Qp/PB)*R+(Qc*(1-1)*(Qc*1+Qp/PB)*Qc*1*Clu)/Plu}{(Qc+0)*(Qc*1+Qp/PB)*(Qc+1*0)-(Qc*1+Qp/PB)*pow(Qc*(1-1),2)}$$

$$= (Qc*(Qc+Qp/PB)*R) / ((Qc)*(Qc+Qp/PB)*(Qc)) = R/Qc$$

$$Cpulv = \frac{(Qc+1*0)*(Qc+0)*Qin+(Qc*(1-1)*Qc*1*Qc*1*Clu)/Plu+(Qc+1*0)*Qc*1*R-Qin*pow(Qc*(1-1),2)}{(Qc+0)*(Qc*1+Qp/PB)*(Qc+1*0)-(Qc*1+Qp/PB)*pow(Qc*(1-1),2)}$$

$$= ((Qc)*(Qc)*Qin+(Qc)*Qc*R) / ((Qc)*(Qc+Qp/PB)*(Qc)) = (Qin+R) / (Qc+Qp/PB)$$

$$= (Qin + Qc*Cven) / ((Qc+Qp/PB))$$

$$Cart = \frac{((Qc+0)*(Qc*1+Qp/PB)*Qc*1*Clu)/Plu+Qc*(1-1)*(Qc*1+Qp/PB)*R}{(Qc+0)*(Qc*1+Qp/PB)*(Qc+1*0)-(Qc*1+Qp/PB)*pow(Qc*(1-1),2)}$$

$$= (((Qc)*(Qc+Qp/PB)*Qc*Clu)/Plu) / ((Qc)*(Qc+Qp/PB)*(Qc)) = Clu/Plu$$

Implementing the steady state approximations for blood compartments,

without explicit lung tissue

Using YACAS (symbolic algebra tool) online: https://www.yacas.org/yacas_online/yacas_online.html

Relevant Documentation:

https://yacas.readthedocs.io/en/latest/reference_manual/linear-algebra.html#SolveMatrix

https://yacas.readthedocs.io/en/latest/reference_manual/io.html#CForm

```
M:={{Qc+L,0,-Qc*(1-F)},{-Qc*F,Qc*F+Qp/PB,0},{-Qc*(1-F),-Qc*F,Qc+F*kG}}
x:={{Cv},{Cp},{Ca}}
b:={{R},{Qin},{0}}
x := SolveMatrix(M, b)
```

```
R = R_IV + R_Qtis_out
Qin = Q_p*F_inh*C_inh
L = k_ven_ust*V_ven + k_loss
```

```
CForm(x[1])
( (Qc+F*kG)*(Qc*F+Qp/PB)*R+Qc*F*Qc*(1−F)*Qin ) /
    ( (Qc+L)*(Qc*F+Qp/PB)*(Qc+F*kG)−Qc*(1−F)*pow(Qc*F,2)−(Qc*F+Qp/PB)*pow(Qc*(1−F),2) )
CForm(x[2])
( (Qc+F*kG)*(Qc+L)*Qin+(Qc+F*kG)*Qc*F*R−Qin*pow(Qc*(1−F),2) ) /
    ( (Qc+L)*(Qc*F+Qp/PB)*(Qc+F*kG)−Qc*(1−F)*pow(Qc*F,2)−(Qc*F+Qp/PB)*pow(Qc*(1−F),2) )
CForm(x[3])
( Qc*F*(Qc+L)*Qin+R*pow(Qc*F,2)+Qc*(1−F)*(Qc*F+Qp/PB)*R ) /
    ( (Qc+L)*(Qc*F+Qp/PB)*(Qc+F*kG)−Qc*(1−F)*pow(Qc*F,2)−(Qc*F+Qp/PB)*pow(Qc*(1−F),2) )
```

$R = R_{IV} + R_{Qtis\_out}$
$Qin = Q_p * F_{inh} * C_{inh}$
$L = k_{ven\_ust} \ast V_{ven} + k_{loss}$

Implementing the steady state approximations for blood compartments,
without explicit lung tissue

From previous:

$$Cven = ((Qc+F\ast kG)\ast(Qc\ast F+Qp/PB)\ast R+Qc\ast F\ast Qc\ast(1-F)\ast Qin) /$$
$$((Qc+L)\ast(Qc\ast F+Qp/PB)\ast(Qc+F\ast kG)-Qc\ast(1-F)\ast \mathrm{pow}(Qc\ast F,2)-(Qc\ast F+Qp/PB)\ast \mathrm{pow}(Qc\ast(1-F),2))$$

$$Cpulv = ((Qc+F\ast kG)\ast(Qc+L)\ast Qin+(Qc+F\ast kG)\ast Qc\ast F\ast R-Qin\ast \mathrm{pow}(Qc\ast(1-F),2)) /$$
$$((Qc+L)\ast(Qc\ast F+Qp/PB)\ast(Qc+F\ast kG)-Qc\ast(1-F)\ast \mathrm{pow}(Qc\ast F,2)-(Qc\ast F+Qp/PB)\ast \mathrm{pow}(Qc\ast(1-F),2))$$

$$Cart = (Qc\ast F\ast(Qc+L)\ast Qin+R\ast \mathrm{pow}(Qc\ast F,2)+Qc\ast(1-F)\ast(Qc\ast F+Qp/PB)\ast R) /$$
$$((Qc+L)\ast(Qc\ast F+Qp/PB)\ast(Qc+F\ast kG)-Qc\ast(1-F)\ast \mathrm{pow}(Qc\ast F,2)-(Qc\ast F+Qp/PB)\ast \mathrm{pow}(Qc\ast(1-F),2))$$

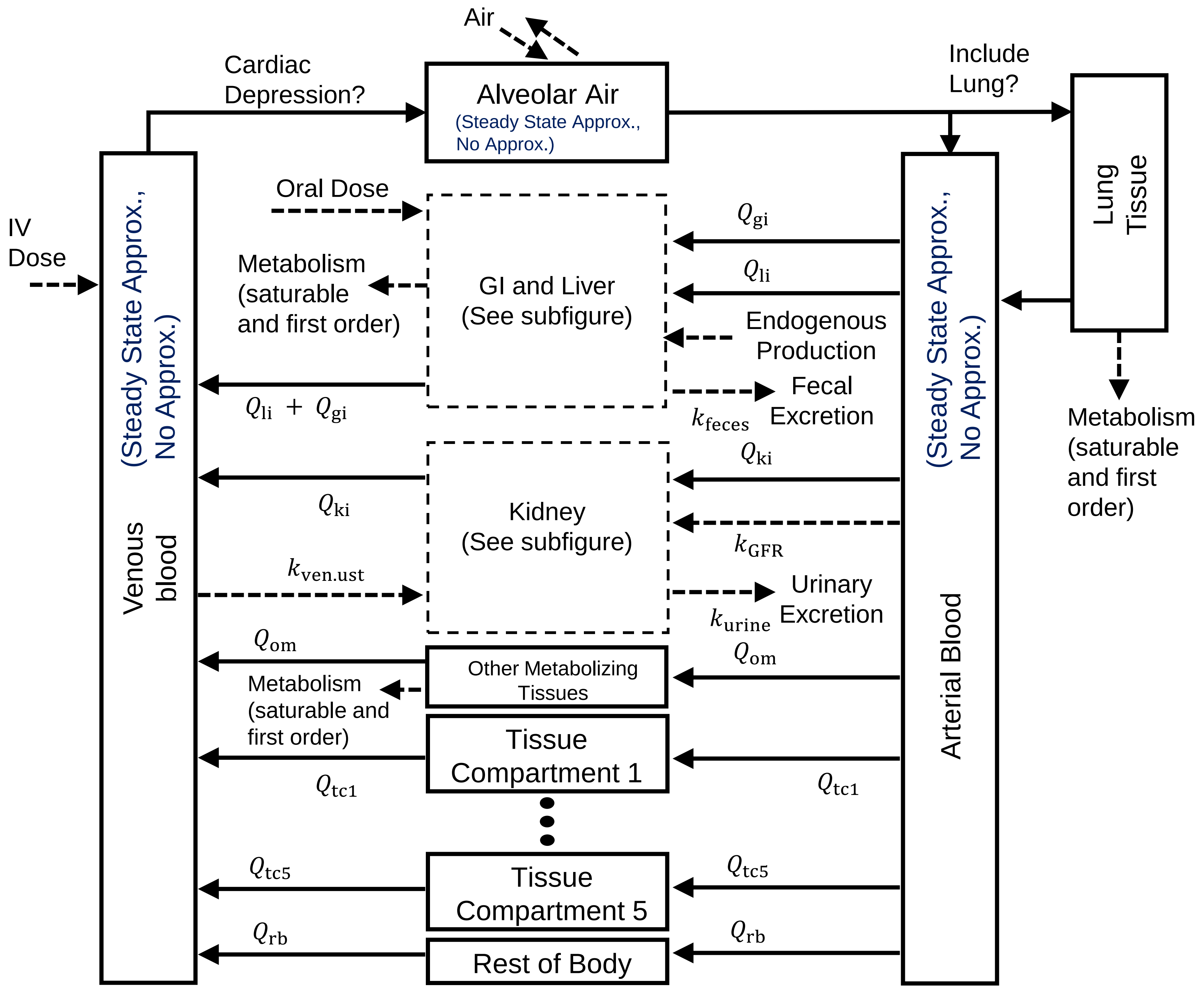
If $F=1$, $kG=0$, $L=0$:

$$Cven = ((Qc+1\ast 0)\ast(Qc\ast 1+Qp/PB)\ast R+Qc\ast 1\ast Qc\ast(1-1)\ast Qin) /$$
$$((Qc+0)\ast(Qc\ast 1+Qp/PB)\ast(Qc+1\ast 0)-Qc\ast(1-1)\ast \mathrm{pow}(Qc\ast 1,2)-(Qc\ast 1+Qp/PB)\ast \mathrm{pow}(Qc\ast(1-1),2))$$
$$= ((Qc)\ast(Qc+Qp/PB)\ast R) / ((Qc)\ast(Qc+Qp/PB)\ast(Qc)) = R/Qc$$

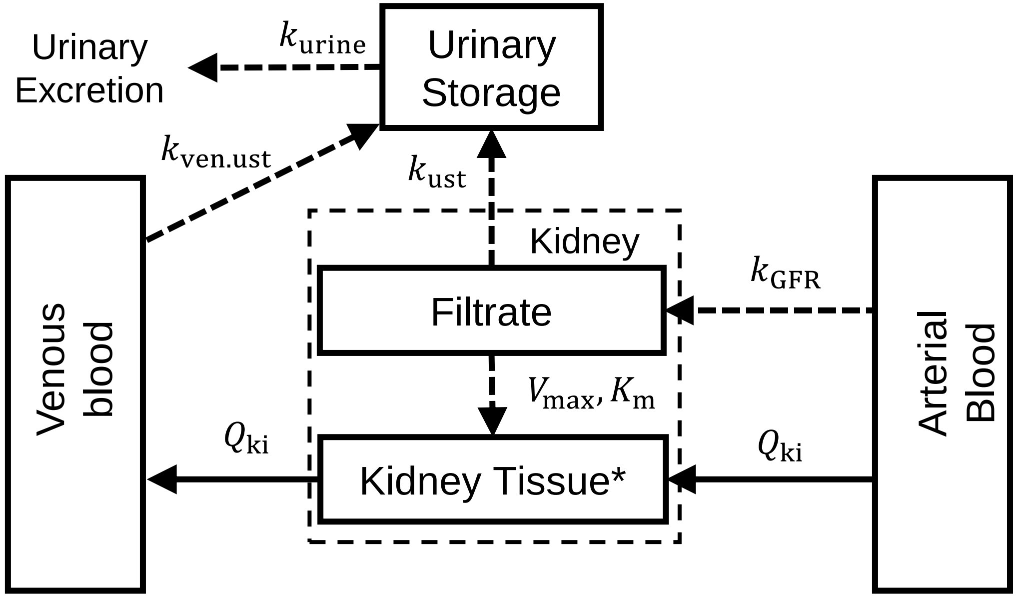
$$Cpulv = ((Qc+1\ast 0)\ast(Qc+0)\ast Qin+(Qc+1\ast 0)\ast Qc\ast 1\ast R-Qin\ast \mathrm{pow}(Qc\ast(1-1),2)) /$$
$$((Qc+0)\ast(Qc\ast 1+Qp/PB)\ast(Qc+1\ast 0)-Qc\ast(1-1)\ast \mathrm{pow}(Qc\ast 1,2)-(Qc\ast 1+Qp/PB)\ast \mathrm{pow}(Qc\ast(1-1),2))$$
$$= ((Qc)\ast(Qc)\ast Qin+(Qc)\ast Qc\ast R) / (Qc)\ast(Qc+Qp/PB)\ast(Qc)) = (Qin + R) / ((Qc+Qp/PB))$$
$$= (Qin + Qc * Cven) / ((Qc+Qp/PB))$$

$$Cart = (Qc\ast 1\ast(Qc+0)\ast Qin+R\ast \mathrm{pow}(Qc\ast 1,2)+Qc\ast(1-1)\ast(Qc\ast 1+Qp/PB)\ast R) /$$
$$((Qc+0)\ast(Qc\ast 1+Qp/PB)\ast(Qc+1\ast 0)-Qc\ast(1-1)\ast \mathrm{pow}(Qc\ast 1,2)-(Qc\ast 1+Qp/PB)\ast \mathrm{pow}(Qc\ast(1-1),2))$$
$$= (Qc\ast(Qc)\ast Qin+R\ast \mathrm{pow}(Qc,2)) / (Qc)\ast(Qc+Qp/PB)\ast(Qc)) = (Qin+R) / (Qc+Qp/PB) = Cpulv$$

Template Model



Kidney Subfigure



Liver and GI Subfigure