Supplementary Materials

Key Model Equations and Parameters

Surgical bleeding scenario

FFP_number(t) = FFP_number(t - dt) + (FFP_counter) * dtINITFFP_number = 0
INFLOWS:
FFP_counter = IF(FFP_transfuse_Pool=125) THEN(PULSE(1,0))ELSE(0)
FFP_time_recoreder(t) = FFP_time_recoreder(t - dt) + (FFT_time) * dtINITFFP_time_recoreder = 0
INFLOWS:
FFT_time = IF(FFP>0) THEN(PULSE(TIME-FFP_time_recoreder,0)) ELSE(0)
FFP_transfuse_Pool(t) = FFP_transfuse_Pool(t - dt) + (FFP - FFP_infusion_rate) * dtINITFFP_transfuse_Pool = 0
INFLOWS:
FFP = IF(Plasma_dilution_percent<30 AND(FFP_transfuse_Pool=0))THEN(PULSE(125,0))ELSE(0)
OUTFLOWS:
FFP_infusion_rate = IF(FFP_transfuse_Pool>0)THEN(125/10)ELSE(0)
Fibrinogen_pool(t) = Fibrinogen_pool(t - dt) + (Fibrinogen_Gain - Fibrinogen_Loss) * dtINITFibrinogen_pool = 4900*3
INFLOWS:
Fibrinogen_Gain = (FFP_infusion_rate+PC_plasma_infusion_rate+pRBC_plasma_infusion_rate)*3*400/230
OUTFLOWS:
Fibrinogen_Loss = Fibrinogen_pool*Bleeding_rate/Calculated_blood_volume
Intravascular_water_compartment(t) = Intravascular_water_compartment(t - dt) + (volume_replacement - Intravascular_water_loss_rate) * dtINITIntravascular_water_compartment = 0
INFLOWS:
volume_replacement = Bleeding_rate-pRBC_plasma_infusion_rate-FFP_infusion_rate-PC_plasma_infusion_rate-RBC_transfusion_rate
OUTFLOWS:
Intravascular_water_loss_rate = Bleeding_rate*Intravascular_water_compartment/Calculated_blood_volume
PC_number(t) = PC_number(t - dt) + (PC_counter) * dtINITPC_number = 0
INFLOWS:
PC_counter = IF(PC_plasma_transfusion_pool=40) THEN(PULSE(1,0))ELSE(0)
PC_plasma_transfusion_pool(t) = PC_plasma_transfusion_pool(t - dt) + (PC_plasma_transfusion_refill - PC_plasma_infusion_rate) * dtINITPC_plasma_transfusion_pool = 0
INFLOWS:
PC_plasma_transfusion_refill = IF(Adjusted_platelet_count<50000 AND(PC_plasma_transfusion_pool=0))THEN(PULSE(40,0))ELSE(0)
OUTFLOWS:
PC_plasma_infusion_rate = IF(PC_plasma_transfusion_pool>0)THEN(40/5)ELSE(0)
Plasma_compartment(t) = Plasma_compartment(t - dt) + (FFP_infusion_rate + pRBC_plasma_infusion_rate + PC_plasma_infusion_rate - Plsma_loss_rate) * dtINITPlasma_compartment = 2842
INFLOWS:
FFP_infusion_rate = IF(FFP_transfuse_Pool>0)THEN(125/10)ELSE(0)
pRBC_plasma_infusion_rate = IF(RBC_Plasma_transfusion_pool>0)THEN(56/10)ELSE(0)
PC_plasma_infusion_rate = IF(PC_plasma_transfusion_pool>0)THEN(40/5)ELSE(0)
OUTFLOWS:
Plsma_loss_rate = Bleeding_rate*Plasma_compartment/Calculated_blood_volume
Platelets_pool(t) = Platelets_pool(t - dt) + (Platelets_gain - Platelets_loss) * dtINITPlatelets_pool = 230*4900*10^6
INFLOWS:
Platelets_gain = PC_plasma_infusion_rate/40*66.7*0.67*10^9
OUTFLOWS:
Platelets_loss = Bleeding_rate*(Platelets_pool/Calculated_blood_volume)

pRBC_time_recoreder(t) = pRBC_time_recoreder(t - dt) + (pRBC_time) * dtINITpRBC_time_recoreder = 0
INFLOWS:
pRBC_time = IF(RBC_transfusion_refill>0)THEN(PULSE(TIME-pRBC_time_recoreder,0))ELSE(0)
PRC_number(t) = PRC_number(t - dt) + (PRC_counter) * dtINITPRC_number = 0
INFLOWS:
PRC_counter = IF(RBC_transfusion_Pool=170) THEN(PULSE(1,0))ELSE(0)
RBC_Compartment(t) = RBC_Compartment(t - dt) + (RBC_transfusion_rate - RBC_loss_rate) * dtINITRBC_Compartment = 2058
INFLOWS:
RBC_transfusion_rate = IF(RBC_transfusion_Pool>0)THEN(170/10)ELSE(0)
OUTFLOWS:
RBC_loss_rate = Bleeding_rate*RBC_Compartment/Calculated_blood_volume
RBC_Plasma_transfusion_pool(t) = RBC_Plasma_transfusion_pool(t - dt) + (pRBC_plasma_transfusion_refill - pRBC_plasma_infusion_rate) * dtINITRBC_Plasma_transfusion_pool = 0
INFLOWS:
pRBC_plasma_transfusion_refill = IF(Hematocrit<27 AND (RBC_Plasma_transfusion_pool=0))THEN(PULSE(56,0))ELSE(0)
OUTFLOWS:
pRBC_plasma_infusion_rate = IF(RBC_Plasma_transfusion_pool>0)THEN(56/10)ELSE(0)
RBC_transfusion_Pool(t) = RBC_transfusion_Pool(t - dt) + (RBC_transfusion_refill - RBC_transfusion_rate) * dtINITRBC_transfusion_Pool = 0
INFLOWS:
RBC_transfusion_refill = IF(Hematocrit<27 AND(RBC_transfusion_Pool=0))THEN(PULSE(170,0))ELSE(0)
OUTFLOWS:
RBC_transfusion_rate = IF(RBC_transfusion_Pool>0)THEN(170/10)ELSE(0)
Total_Plasma_loss(t) = Total_Plasma_loss(t - dt) + (Plsma_loss_rate) * dtINITTotal_Plasma_loss = 0
INFLOWS:
Plsma_loss_rate = Bleeding_rate*Plasma_compartment/Calculated_blood_volume
Total_RBC_loss(t) = Total_RBC_loss(t - dt) + (RBC_loss_rate) * dtINITTotal_RBC_loss = 0
INFLOWS:
RBC_loss_rate = Bleeding_rate*RBC_Compartment/Calculated_blood_volume
Total_water_loss(t) = Total_water_loss(t - dt) + (Intravascular_water_loss_rate) * dtINITTotal_water_loss = 0
INFLOWS:
Intravascular_water_loss_rate = Bleeding_rate*Intravascular_water_compartment/Calculated_blood_volume
Adjusted_platelet_count = 230000*Platelets_adjustement_factor/100
Bleeding_fraction = Combined_volume_of_bleeding/4900
Bleeding_rate = 50
Calculated_blood_volume = Intravascular_water_compartment+Plasma_compartment+RBC_Compartment
Combined_volume_of_bleeding = Total_Plasma_loss+Total_RBC_loss+Total_water_loss
Fibrinogen_level = Fibrinogen_pool/Calculated_blood_volume
Hematocrit = RBC_Compartment/Calculated_blood_volume*100
Percent_calculated_platelets = Uncorreted_platelets_count/230000*100
Plasma_dilution_percent = (Plasma_compartment/Calculated_blood_volume)/(2842/4900)*100
Uncorreted_platelets_count = Platelets_pool/(Calculated_blood_volume*10^3)
Platelets_adjustement_factor = GRAPH(Percent_calculated_platelets)
(0.00, 7.00), (10.0, 21.0), (20.0, 32.0), (30.0, 43.0), (40.0, 52.0), (50.0, 60.0), (60.0, 69.0), (70.0, 77.0), (80.0, 83.0), (90.0, 91.0), (100, 100)
PT_dilution_curve = GRAPH(Plasma_dilution_percent)
(0.00, 200), (10.0, 58.0), (20.0, 34.2), (30.0, 24.9), (40.0, 18.6), (50.0, 15.9), (60.0, 14.6), (70.0, 13.5), (80.0, 12.6), (90.0, 12.2), (100, 11.8)

Traumatic bleeding scenario

FFP_number(t) = FFP_number(t - dt) + (FFP_counter) * dtINITFFP_number = 0
INFLOWS:
FFP_counter = IF(FFP_transfuse_Pool=125) THEN(PULSE(1,0)) ELSE(0)
FFP_time_recoreder(t) = FFP_time_recoreder(t - dt) + (FFT_time) * dtINITFFP_time_recoreder = 0
INFLOWS:
FFT_time = IF(FFP>0) THEN(PULSE(TIME-FFP_time_recoreder,0)) ELSE(0)
FFP_transfuse_Pool(t) = FFP_transfuse_Pool(t - dt) + (FFP - FFP_infusion_rate) * dtINITFFP_transfuse_Pool = 0
INFLOWS:
FFP = IF(Plasma_dilution_percent<30 AND(FFP_transfuse_Pool=0))THEN(PULSE(125,0))ELSE(0)
OUTFLOWS:
FFP_infusion_rate = IF(FFP_transfuse_Pool>0) THEN(125/10) ELSE(0)
Fibrinogen_pool(t) = Fibrinogen_pool(t - dt) + (Fibrinogen_Gain - Fibrinogen_Loss) * dtINITFibrinogen_pool = 4900*3
INFLOWS:
Fibrinogen_Gain = (FFP_infusion_rate+PC_plasma_infusion_rate+pRBC_plasma_infusion_rate)*3*400/230
OUTFLOWS:
Fibrinogen_Loss = Fibrinogen_pool*Bleeding_rate/Calculated_blood_volume
Intravascular_water_compartment(t) = Intravascular_water_compartment(t - dt) + (Crystalloid_infusion_rate + Transcapillary_refill_rate + OR_water - Intravascular_water_loss_rate) * dtINITIntravascular_water_compartment = 0
INFLOWS:
Crystalloid_infusion_rate = Crystalloid_rate_calcurator/Crystalloid_retention_ratio
Transcapillary_refill_rate = IF(Transcapillary_filling_volume<=(4900*0.15))THEN(0.00013*5000*(120-SBP))ELSE(0)
OR_water = IF(TIME>70) THEN(50-FFP_infusion_rate-PC_plasma_infusion_rate-pRBC_plasma_infusion_rate-RBC_transfusion_rate) ELSE(0)
OUTFLOWS:
Intravascular_water_loss_rate = Bleeding_rate*Intravascular_water_compartment/Calculated_blood_volume
PC_number(t) = PC_number(t - dt) + (PC_counter) * dtINITPC_number = 0
INFLOWS:
PC_counter = IF(PC_plasma_transfusion_pool=40) THEN(PULSE(1,0)) ELSE(0)
PC_plasma_transfusion_pool(t) = PC_plasma_transfusion_pool(t - dt) + (PC_plasma_transfusion_refill - PC_plasma_infusion_rate) * dtINITPC_plasma_transfusion_pool = 0
INFLOWS:
PC_plasma_transfusion_refill = IF(Adjusted_platelet_count<50000 AND(PC_plasma_transfusion_pool=0))THEN(PULSE(40,0))ELSE(0)
OUTFLOWS:
PC_plasma_infusion_rate = IF(PC_plasma_transfusion_pool>0)THEN(40/5)ELSE(0)
Plasma_compartment(t) = Plasma_compartment(t - dt) + (FFP_infusion_rate + pRBC_plasma_infusion_rate + PC_plasma_infusion_rate - Plsma_loss_rate) * dtINITPlasma_compartment = 2842
INFLOWS:
FFP_infusion_rate = IF(FFP_transfuse_Pool>0) THEN(125/10) ELSE(0)
pRBC_plasma_infusion_rate = IF(RBC_Plasma_transfusion_pool>0) THEN(56/10)ELSE(0)
PC_plasma_infusion_rate = IF(PC_plasma_transfusion_pool>0)THEN(40/5)ELSE(0)
OUTFLOWS:
Plsma_loss_rate = Bleeding_rate*Plasma_compartment/Calculated_blood_volume
Platelets_pool(t) = Platelets_pool(t - dt) + (Platelets_gain - Platelets_loss) * dtINITPlatelets_pool = 230*4900*10^6
INFLOWS:
Platelets_gain = PC_plasma_infusion_rate/40*66.7*0.67*10^9
OUTFLOWS:
Platelets_loss = Bleeding_rate*(Platelets_pool/Calculated_blood_volume)
pRBC_time_recoreder(t) = pRBC_time_recoreder(t - dt) + (pRBC_time) * dtINITpRBC_time_recoreder = 0

INFLOWS:
pRBC_time = IF(RBC_transfusion_refill>0)THEN(PULSE(TIME-pRBC_time_recoreder,0))ELSE(0)
PRC_number(t) = PRC_number(t - dt) + (PRC_counter) * dtINITPRC_number = 0
INFLOWS:
PRC_counter = IF(RBC_transfusion_Pool=170) THEN(PULSE(1.0))ELSE(0)
RBC_Compartment(t) = RBC_Compartment(t - dt) + (RBC_transfusion_rate - RBC_loss_rate) * dtINITRBC_Compartment = 2058
INFLOWS:
RBC_transfusion_rate = IF(RBC_transfusion_Pool>0) THEN(170/10)ELSE(0)
OUTFLOWS:
RBC_loss_rate = Bleeding_rate*RBC_Compartment/Calculated_blood_volume
RBC_Plasma_transfusion_pool(t) = RBC_Plasma_transfusion_pool(t - dt) + (pRBC_plasma_transfusion_refill - pRBC_plasma_infusion_rate) * dtINITRBC_Plasma_transfusion_pool = 0
INFLOWS:
pRBC_plasma_transfusion_refill = IF(TIME>50 AND Hematocrit<27 AND (RBC_Plasma_transfusion_pool=0))THEN(PULSE(56,0))ELSE(0)
OUTFLOWS:
pRBC_plasma_infusion_rate = IF(RBC_Plasma_transfusion_pool>0) THEN(56/10)ELSE(0)
RBC_transfusion_Pool(t) = RBC_transfusion_Pool(t - dt) + (RBC_transfusion_refill - RBC_transfusion_rate) * dtINITRBC_transfusion_Pool = 0
INFLOWS:
RBC_transfusion_refill = IF(TIME>50 AND Hematocrit<27 AND(RBC_transfusion_Pool=0))THEN(PULSE(170,0))ELSE(0)
OUTFLOWS:
RBC_transfusion_rate = IF(RBC_transfusion_Pool>0) THEN(170/10)ELSE(0)
Total_Plasma_loss(t) = Total_Plasma_loss(t - dt) + (Plsma_loss_rate) * dtINITTotal_Plasma_loss = 0
INFLOWS:
Plsma_loss_rate = Bleeding_rate*Plasma_compartment/Calculated_blood_volume
Total_RBC_loss(t) = Total_RBC_loss(t - dt) + (RBC_loss_rate) * dtINITTotal_RBC_loss = 0
INFLOWS:
RBC_loss_rate = Bleeding_rate*RBC_Compartment/Calculated_blood_volume
Total_water_loss(t) = Total_water_loss(t - dt) + (Intravascular_water_loss_rate) * dtINITTotal_water_loss = 0
INFLOWS:
Intravascular_water_loss_rate = Bleeding_rate*Intravascular_water_compartment/Calculated_blood_volume
Transcapillary_filling_volume(t) = Transcapillary_filling_volume(t - dt) + (Capillary_filling_rate) * dtINITTranscapillary_filling_volume = 0
INFLOWS:
Capillary_filling_rate = Transcapillary_refill_rate
Adjusted_platelet_count = 230000*Platelets_adjustement_factor/100
Bleeding_fraction = Combined_volume_of_bleeding/4900
Bleeding_rate = IF(TIME<70) THEN(((Initial_bleeding_rate*SBP)/120)*Hemostatic_factor)ELSE(50)
Calculated_blood_volume = Intravascular_water_compartment+Plasma_compartment+RBC_Compartment
Combined_volume_of_bleeding = Total_Plasma_loss+Total_RBC_loss+Total_water_loss
Crystalloid_rate_calcurator = ER_Crystalloid_rate
Crystalloid_retention_ratio = IF(4.88+(0.01*(EXP(Percent_hemorrhage/13.4)))<7) THEN(4.88+(0.01*(EXP(Percent_hemorrhage/13.4))))ELSE(7)
ER_Crystalloid_rate = IF(TIME>31)AND(TIME<70)THEN(300)ELSE(50)
Fibrinogen_level = Fibrinogen_pool/Calculated_blood_volume
Hematocrit = RBC_Compartment/Calculated_blood_volume*100
Initial_bleeding_rate = 50
Percent_calculated_platelets = Uncorreted_platelets_count/230000*100
Percent_hemorrhage = (1-Calculated_blood_volume/4900)*100
Plasma_dilution_percent = (Plasma_compartment/Calculated_blood_volume)/(2695/4900)*100
SBP = 120*(1-(4900-Calculated_blood_volume)/2450)

Uncorreted_platelets_count = Platelets_pool/(Calculated_blood_volume*10^3)
Hemostatic_factor = GRAPH(SBP)
(0.00, 0.00), (10.0, 0.00), (20.0, 0.00), (30.0, 0.00), (40.0, 0.00), (50.0, 0.00), (60.0, 0.2), (70.0, 0.4), (80.0, 0.7), (90.0, 1.00), (100, 1.00), (110, 1.00), (120, 1.00), (130, 1.00)
Platelets_adjustement_factor = GRAPH(Percent_calculated_platelets)
(0.00, 7.00), (10.0, 21.0), (20.0, 32.0), (30.0, 43.0), (40.0, 52.0), (50.0, 60.0), (60.0, 69.0), (70.0, 77.0), (80.0, 83.0), (90.0, 91.0), (100, 100)
PT_dilution_curve = GRAPH(Plasma_dilution_percent)
(0.00, 200), (10.0, 58.0), (20.0, 34.2), (30.0, 24.9), (40.0, 18.6), (50.0, 15.9), (60.0, 14.6), (70.0, 13.5), (80.0, 12.6), (90.0, 12.2), (100, 11.8)

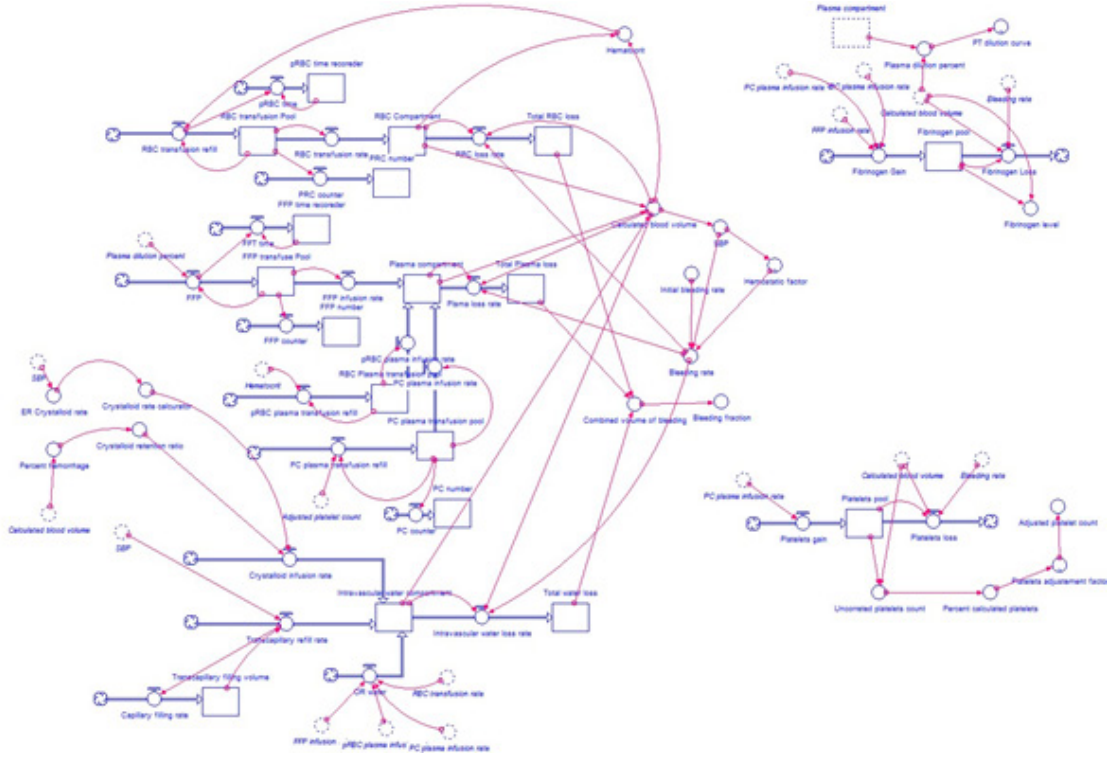

Diagram of the STELLA model of intravascular volume changes in a bleeding adult patient with the intraoperative bleeding scenario. The intravascular volume (accumulation) is represented by a rectangle. Bleeding, rebleeding, transcapillary refill, and crystalloid administration are control variables (flows) that update the intravascular volume every 0.01 minute. Factors affecting the flow are marked by circles.

Diagram of the STELLA model of intravascular volume changes in a bleeding adult patient with the trauma bleeding scenario. The intravascular volume (accumulation) is represented by a rectangle, while bleeding, rebleeding, transcapillary refill, and crystalloid administration are control variables (flows) that update the intravascular volume every 0.01 minute. Factors affecting the flow are marked by circles.