

User Manual: sO2 and Hematocrit Calculator

Introduction

The sO2 and Hct calculator is developed by Josh Bradshaw, using Sharon Portnoy's body of work. It is based on *Relaxation Properties of Human Umbilical Cord Blood at 1.5 Tesla* - Magnetic Resonance in Medicine 00:00–00 (2016), and a more recent manuscript which has not yet been published. The motivation for this tool is to provide clinical researchers with a user-friendly and robust means of doing these calculations.

Inputs:

- Input Type: T1_T2
- T1 (ms)
- T2 (ms)
- tau_180 (ms)
- sO2 (decimal)
- Hct (decimal)
- Field Strength: 1.5T
- Vessel Type: Fetal

Outputs:

- sO2 (decimal)
- Hct (decimal)

SOLVE

Created by Josh Bradshaw, using Sharon Portney's manuscript.
Cite: [INSERT MANUSCRIPT CITATION HERE]
MIT Licensed

Figure 1: sO2 and Hematocrit calculator version 1.0.

Setting up the calculator

The calculator supports three primary modes of operation:

1. Given T1, and T2, calculate sO2 and Hct
2. Given T1 and sO2, calculate Hct
3. Given T2 and Hct, calculate sO2

These modes can be selected by setting the input type selector to the appropriate input type:

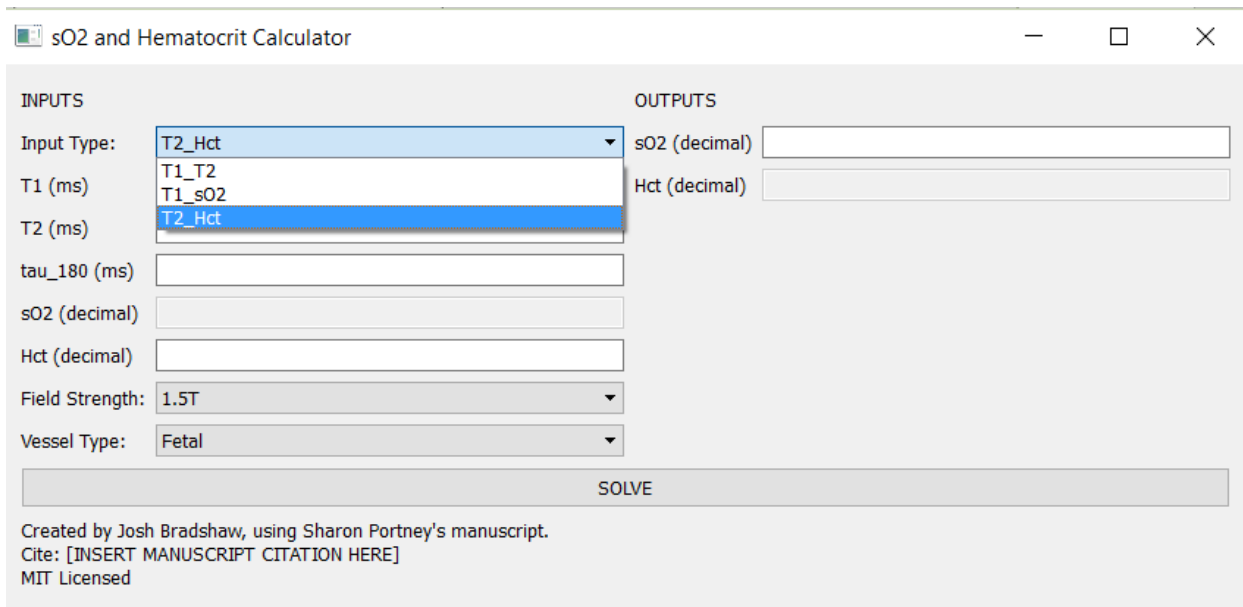


Figure 2: Selecting the mode of operation

After selecting the correct mode of operation, the field strength and vessel type fields must be set correctly. The three field strength options are:

1. 1.5T
2. 3T
3. 1.5T variable tau_180

The 1.5T variable tau_180 option isn't a true field strength option per say. It's just a little bodge to support the old pulse sequence that we previously used on 1.5T that had variable intervals between refocusing pulses, and thus requires a different analysis.

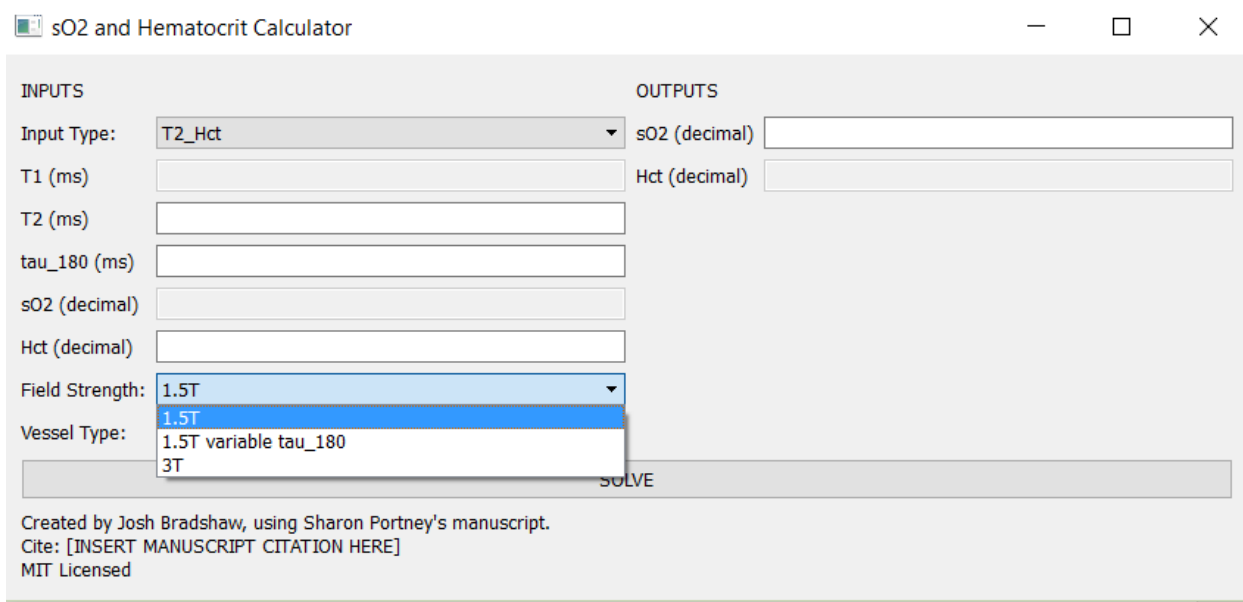


Figure 3: Selecting the field strength

At time of writing, all of the combinations work except for 3T. The 3T parameters will be retroactively added by Sharon Portnoy after she finishes calculating them.

Performing the calculation

Once the input type, field strength and vessel type parameters are set correctly, performing the calculation is a simple matter. A few sample calculations are provided below:

Example calculation with T1, T2 and Tau_180 as input

INPUTS	OUTPUTS
Input Type: T1_T2	sO2 (decimal) (2.033 + 0.000i) (1.553 + 0.000i) (0.529 + 0.000i)
T1 (ms) 1540	Hct (decimal) (0.994 + 0.000i) (0.599 + 0.000i) (0.324 + 0.000i)
T2 (ms) 96.7	
tau_180 (ms) 16	
sO2 (decimal)	
Hct (decimal)	
Field Strength: 1.5T	
Vessel Type: Fetal	

Created by Josh Bradshaw, using Sharon Portney's manuscript.
Cite: [INSERT MANUSCRIPT CITATION HERE]
MIT Licensed

Figure 5: Sample Calculation with T1 and T2 input.

The calculator solves a cubic system of equations so it will typically output three pairs of numbers, which are the roots of the cubic equation. The Hct solutions are vertically aligned with their corresponding sO2 solutions. The solutions are provided in the standard complex number notation $c = a + bi$. According to Sharon Portnoy's manuscript, the physical possible range for sO2 with measurement error is $\{-0.1 < sO2 < 1.1\}$ and the physical range for hematocrit with measurement error is $\{0.05 < Hct < 1.05\}$.

In this case there is one real solution in the physical range of interest so we take the solution $sO2 = 0.529$ and $Hct = 0.324$ as our solution. We can be confident in this solution, because neither of the other two solutions pairs are in the range of physical possibility, and because physically possible solution is real (has an imaginary part of zero).

Some possible ambiguous cases include:

1. The only physically possible solution has in imaginary part. For example:

sO2 and Hematocrit Calculator

INPUTS	OUTPUTS
Input Type: <input type="text" value="T1_T2"/>	sO2 (decimal) <input type="text" value="(1.411 + 0.000i) (0.798 + 0.170i) (0.798 - 0.170i)"/>
T1 (ms) <input type="text" value="1000"/>	Hct (decimal) <input type="text" value="(1.432 + 0.000i) (0.978 + 0.085i) (0.978 - 0.085i)"/>
T2 (ms) <input type="text" value="190"/>	
tau_180 (ms) <input type="text" value="16"/>	
sO2 (decimal) <input type="text" value=""/>	
Hct (decimal) <input type="text" value=""/>	
Field Strength: <input type="text" value="1.5T"/>	
Vessel Type: <input type="text" value="Fetal"/>	
<input type="button" value="SOLVE"/>	
Created by Josh Bradshaw, using Sharon Portney's manuscript. Cite: [INSERT MANUSCRIPT CITATION HERE] MIT Licensed	

In this case the only physically possible solution is $sO_2 = 0.798$ and $Hct = 0.978$, but this is a complex pair of roots, as opposed to a single real root. In this case both physically possible roots have the same real part, so we simply take the real values to get: $sO_2 = 0.798$ and $Hct = 0.978$.

- Another possible ambiguous case is one in which there are two distinct roots within the range of physical possibility. This case can occur when T_1 is long. If this case arises, send as much information about the problem to Sharon so that she can investigate.

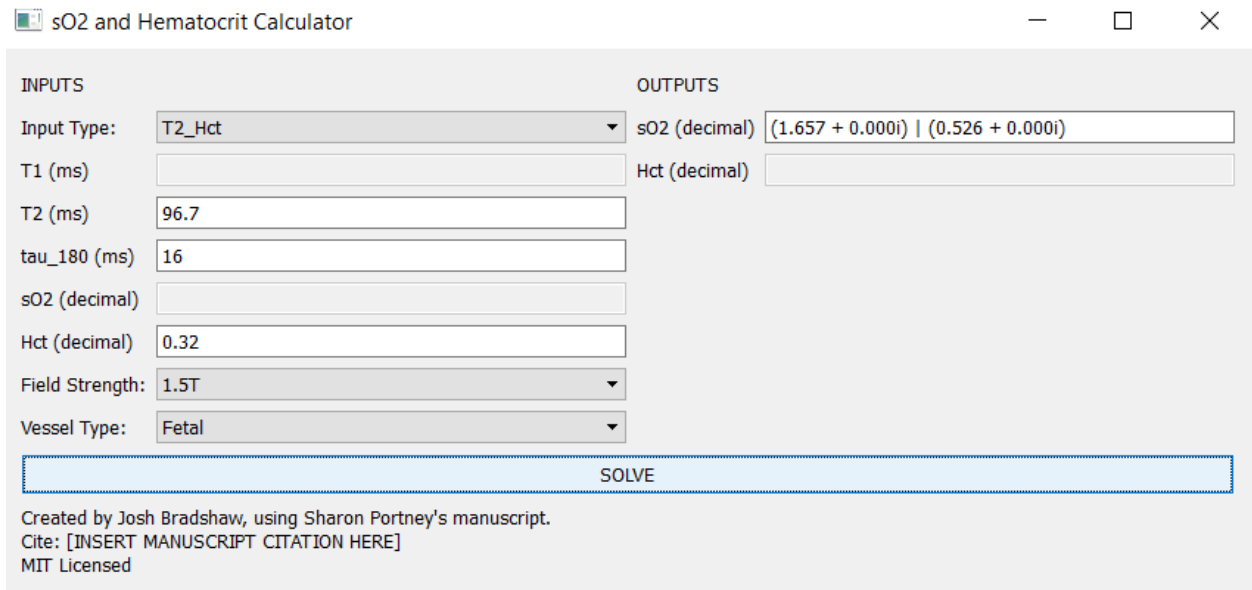
Example calculation using T_1 and sO_2 as input

sO2 and Hematocrit Calculator

INPUTS	OUTPUTS
Input Type: <input type="text" value="T1_sO2"/>	sO2 (decimal) <input type="text" value=""/>
T1 (ms) <input type="text" value="1540"/>	Hct (decimal) <input type="text" value="0.323921784544"/>
T2 (ms) <input type="text" value=""/>	
tau_180 (ms) <input type="text" value=""/>	
sO2 (decimal) <input type="text" value="0.53"/>	
Hct (decimal) <input type="text" value=""/>	
Field Strength: <input type="text" value="1.5T"/>	
Vessel Type: <input type="text" value="Fetal"/>	
<input type="button" value="SOLVE"/>	
Created by Josh Bradshaw, using Sharon Portney's manuscript. Cite: [INSERT MANUSCRIPT CITATION HERE] MIT Licensed	

Figure 6: Sample calculation with T_1 and sO_2 input

Example calculation using T2 and Hct as Input



The screenshot shows a software window titled "sO2 and Hematocrit Calculator". It is divided into two main sections: "INPUTS" and "OUTPUTS".

INPUTS:

- Input Type: T2_Hct (dropdown menu)
- T1 (ms): (empty text box)
- T2 (ms): 96.7 (text box)
- tau_180 (ms): 16 (text box)
- sO2 (decimal): (empty text box)
- Hct (decimal): 0.32 (text box)
- Field Strength: 1.5T (dropdown menu)
- Vessel Type: Fetal (dropdown menu)

OUTPUTS:

- sO2 (decimal): (1.657 + 0.000i) | (0.526 + 0.000i) (text box)
- Hct (decimal): (empty text box)

A "SOLVE" button is located below the input fields. At the bottom of the window, there is a copyright notice: "Created by Josh Bradshaw, using Sharon Portney's manuscript. Cite: [INSERT MANUSCRIPT CITATION HERE] MIT Licensed".

Figure 7: Sample Calculation with T2 and Hct output.

Similarly, to the calculation using T1 and T2 as input, the underlying model for this calculation involves solving a quadratic equation, so it will generally yield two solutions. The same rules for interpretation as in the T1 and T2 case apply.

Testing the Calculator

A simple way to learn how to use the calculator and test that it returns the right answers is to use the numbers from this table:

Summary

Patient	Date	T ₁ (ms)	T ₂ (ms)	Hct	sO ₂
1	07/03	1540	96.70	0.32	0.53
1	07/11	1558	141.41	0.34	0.69
2	06/15	1530	142.6	0.36	0.70
3	06/22	1495	102.46	0.36	0.57
3	07/07	1702	118.57	0.23	0.53
4	06/21	1446	142.95	0.43	0.73
5	07/19	1673	114.99	0.24	0.54

Figure 8: Test data. Fetal 1.5T tau₁₈₀=16ms