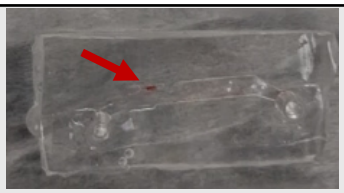
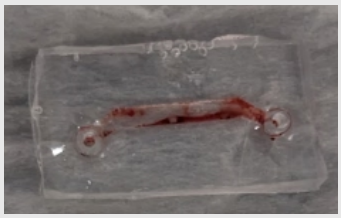
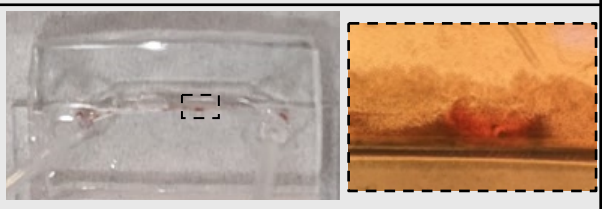
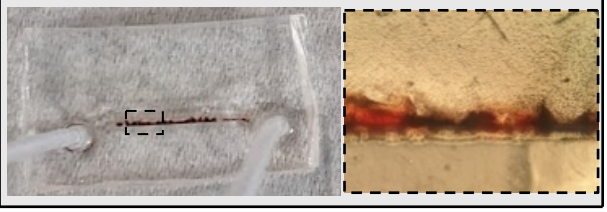
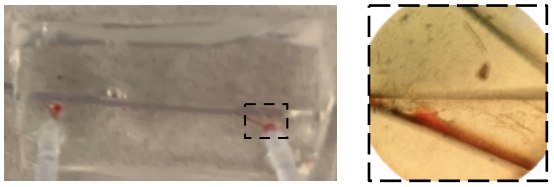
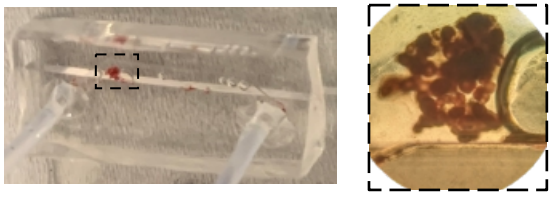
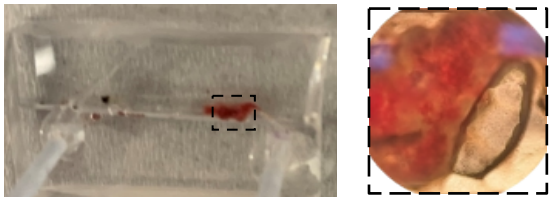
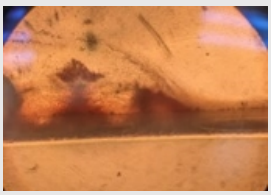
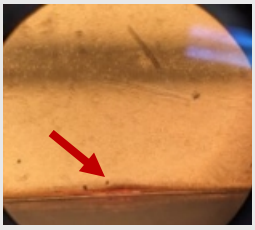
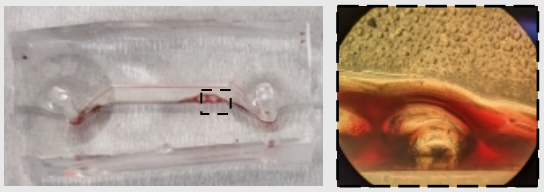
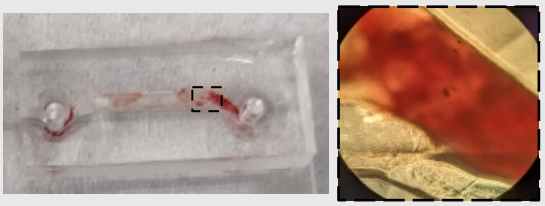
Supplementary 1: The following tables represent the complete data for the coagulation characterization experiments comparing the effect of actuation status and channel height on the coagulation of blood flow through the microchannel. In Phase 1 of the experiments, the focus is on qualitative visualization of coagulation remaining in the channel after the experiment. There, the results are presented in the form of images and qualitative characterization. In general, "minor coagulation" indicates that only small streaks of coagulated blood remained attached to the channel walls after the experiment. "Moderate coagulation" indicates that larger masses of coagulated blood remained which may partially block the channel area, but the flow of fresh blood was able to continue around it. "Total blockage" indicates that major coagulation blocked the entire cross-sectional area of the channel and the flow of blood was stalled. In Phase 2, quantitative results were obtained by measurement of inlet pressure with a high-range manometer. Therefore, results are presented as the time of perfusion of blood before a measurable pressure increase occurred, then the time at which the channel was totally blocked by coagulation, if either event occurred.
"A" actuation status indicates continuous acoustic actuation. "C" indicates control (no actuation applied).

Phase 1: Visual Analysis (No pressure monitoring)

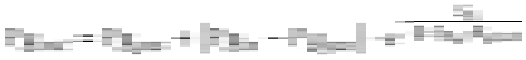
	Sample #	Height (μm)	Actuation Status	Qualitative Result	Image (if available)
Experiment #1	1	600	A	Minor coagulation	
	2	600	C	Total blockage by coagulation	
Experiment #2	1	600	A	Minor coagulation	-
	2	600	C	Minor coagulation	-
Experiment #3	1	600	A	No coagulation	
	2	600	C	Minor coagulation	
	3	250	A	No coagulation	
	4	250	C	Moderate coagulation	

Phase 1: Visual Analysis (No pressure monitoring), Continued					
	Sample #	**Height (μm)**	**Actuation Status**	**Qualitative Result**	**Image (if available)**
Experiment #4	1	600	A	Minor coagulation	
	2	600	C	Moderate coagulation (no blockage)	
	3	250	A	Moderate coagulation	
	4	250	C	Total blockage by coagulation	
Experiment #5	1	600	A	Moderate coagulation	
	2	600	C	Moderate coagulation	
	3	250	A	Minor coagulation	
	4	250	C	Minor coagulation	

Phase 2: Pressure Monitoring by Manometer						
	Sample #	**Height (μm)**	**Actuation Status**	**Time of first pressure increase (min)**	**Time of total blockage (min)**	**Image (if available)**
Experiment #6	1	600	A	No pressure increase	No blockage	
	2	250	C	43	49	
Experiment #7	1	250	A	No pressure increase	No blockage	-
	2	250	C	No pressure increase	No blockage	-
Experiment #8	1	600	A	No pressure increase	No blockage	-
	2	600	C	32	37	-
	3	250	A	No pressure increase	No blockage	-
	4	250	C	1	5	-
Experiment #9	1	600	A	No pressure increase	No blockage	-
	2	250	A	No pressure increase	No blockage	-
Experiment #10	3	250	A	No pressure increase	No blockage	-
	4	250	C	No pressure increase	No blockage	-

Phase 2: Pressure Monitoring by Manometer, Continued						
	Sample #	**Height (μm)**	**Actuation Status**	**Time of first pressure increase (min)**	**Time of total blockage (min)**	**Image (if available)**
Experiment #11	1	250	A	27	32	-
	2	250	C	14	31	-
Experiment #12	1	600	A	12	No blockage	-
	2	250	A	4	17	-

Supplementary 2: The following are calculations made to estimate the CO_2 release performance of the gas exchange device based on the measured values related to oxygenation. We start with the established model for membrane gas exchange for a microchannel [1,2] which can predict the output partial pressure of gas in the blood flow based on inlet conditions and channel geometry. The relevant equations are as follows (note that the equation is symmetric with regard to gas exchange into or out of the microchannel):



(1)

where Pg_{out} is the partial pressure of a gas, g (O_2 or CO_2) in the blood at the outlet of the channel, Pg_{gas} is the partial pressure of g in the gas supply channel, Pg_{in} is the partial pressure of g in the blood at the channel inlet, S_A is the surface area for gas exchange, Q is the flow rate of blood, $S_{B,g}$ is the solubility of g in blood, and $R_{g,tot}$ is the total resistance to gas exchange calculated by:

(2)

where e_m is the thickness of the gas exchange membrane, $P_{m,g}$ is the permeability of the membrane to g, H is the microchannel height, and $D_{B,g}$ is the diffusivity of g in blood. Relevant values are presented in the following table.

Table 1 Parameter values for relevant parameters

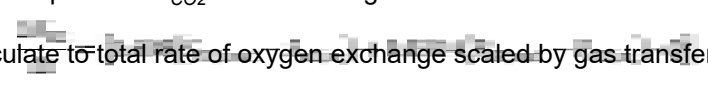
Parameter	Value	Unit	Comment
$P_{O2,out}$ (control)	48.8	mmHg	Measured value for best performing configuration
$P_{O2,out}$ (actuated)	67	mmHg	Measured value for best performing configuration
$P_{O2,gas}$	760	mmHg	Assuming supply of pure oxygen at atmospheric pressure
$P_{CO2,gas}$	0	mmHg	Assuming supply of pure oxygen at atmospheric pressure
$P_{O2,in}$	40.3	mmHg	Measured from veinous draw before channel flow
$P_{CO2,in}$	43	mmHg	Representative, found in [3]
S_A	0.198	cm^2	Calculated according to geometry in Figure 3 (b)
Q	0.05	ml/min	For best performing configuration
$S_{B,O2}$	7.9e-4	$mlO_2\ mlB^{-1}mmHg^{-1}$	[1]
$S_{B,CO2}$	5.05e-3	$mlCO_2\ mlB^{-1}mmHg^{-1}$	[2]
e_m	20	μm	
$P_{m,O2}$	3.6e-7	$mlO_2\ cm^{-1}\ min^{-1}\ mmHg^{-1}$	[1]
$P_{m,CO2}$	1.95e-6	$mlCO_2\ cm^{-1}\ min^{-1}\ mmHg^{-1}$	[1]
H	600	μm	For best performing configuration
$D_{B,O2}$	1.4e-6	$cm^2\ s^{-1}$	[1]
$D_{B,CO2}$	3.05e-6	$cm^2\ s^{-1}$	[2]

We first note that for the geometric parameters of the microchannels used in this study, the relative contribution to gas exchange resistance due to mass transfer through the membrane (left-hand term) is three to four orders of magnitude smaller than the contribution due to solution-diffusion of the gas through the blood volume (right-hand term), and is this therefore negligible in this calculation (5.56×10^3 vs 2.71×10^7 cm^2 min mmHg mlO_2^{-1} for oxygen, for example). Then with only the right-hand term of the equation remaining, resistance to gas exchange will be linearly inversely proportional to the changing effective diffusivity of that gas in the blood volume. The key assumption we will make is that the relative change to the diffusivity value due to active mixing by membrane microstreaming is similar for both O_2 and CO_2, then the relative change to gas exchange resistance will also be similar.

Using that value for resistance to oxygen exchange, given the measured $P_{O2,in}$ of 40.3 mmHg, the theoretical prediction for $P_{O2,out}$ for channel flow with no acoustic actuation by Equation 1 is 48.2 mmHg. This is very close to the measured value of 48.8 mmHg, lending credibility to the equation and experiment. Then, calculating the effective $R_{O2,tot}$ by the measured partial pressure for channel flow with and without actuation, the values are 2.53×10^7 and 7.76×10^6 cm^2 min mmHg mlO_2^{-1}, respectively, indicating the effective diffusivity was increased by a factor of 3.2.

Finally, we use Equations 1 and 2 again to predict the CO_2 release for the case of no actuation, then multiply the calculated effective diffusivity of CO_2 in blood by 3.2 and make the calculation again to estimate the actuated case. With a representative $P_{CO2,in}$ of 43 mmHg, the equations predict ΔP_{CO2} of 1.03 mmHg for the non-actuated and 3.18 mmHg for the actuated case.

At this point, we may also calculate the total rate of oxygen exchange scaled by gas transfer area, $\Delta V_{O2}/\Delta t$, by the relationship in [1]:



(3)

Where $S_{O2,out}$ is the oxygen saturation of blood at the channel inlet, and $S_{O2,in}$ is that at the inlet (93% and 68%, respectively for the best performing configuration). The calculated value is 40 ml/min/m^2.

[1] Potkay, Joseph A. "The promise of microfluidic artificial lungs." *Lab on a Chip* 14.21 (2014): 4122-4138.