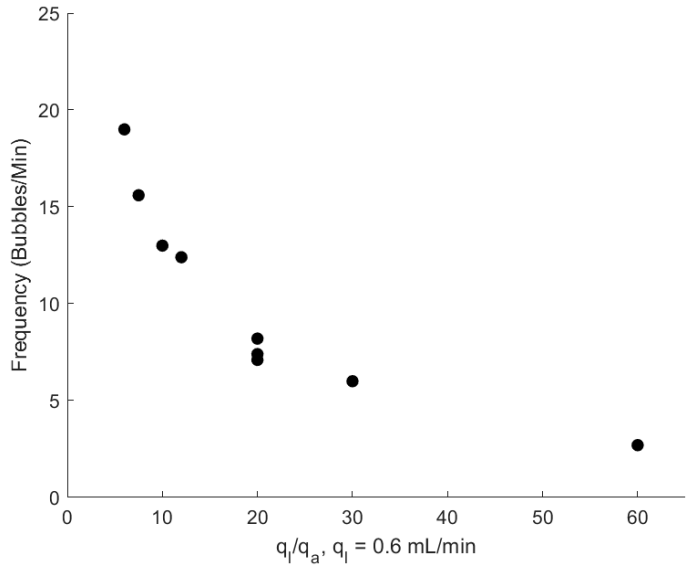
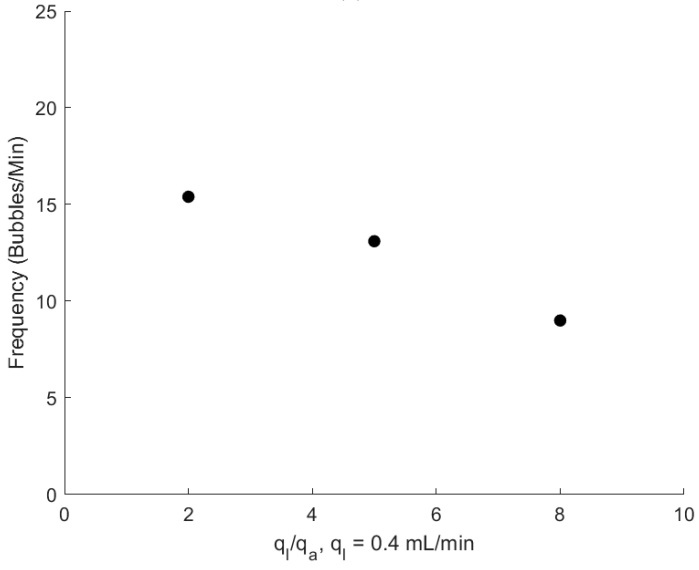
Supporting Information

1. SI. Bubble size and frequency

In order to calibrate the frequency of bubble formation and the size of generated bubble, multiple combinations of liquid flow rate and air flow rate were tested. The size of bubble was described by a continuous function varying with liquid/air ratio, and the frequency of bubble formation was described as a function of the flow ratio for each liquid flow rate. The results for bubble frequencies are shown in Figure 1. Bubble size results are reported in Table 1 of the article.



(a)



(b)

Figure S1. Experimentally determined patterns of frequency based on the bubble generation methods. (a) Bubble frequency when q_l = 0.6 mL/min, and (b) q_l = 0.4 mL/min.

2. SI. Pressure data for experiments

The complete pressure data for the multiphase experiments is reported here. A representative section was used to calculate the average pressure in each experiment, which was used to calculate the hydraulic conductivity. The single-phase baseline pressure was simple and stable for each channel and is not reported but was used to calculate the saturated hydraulic conductivity.

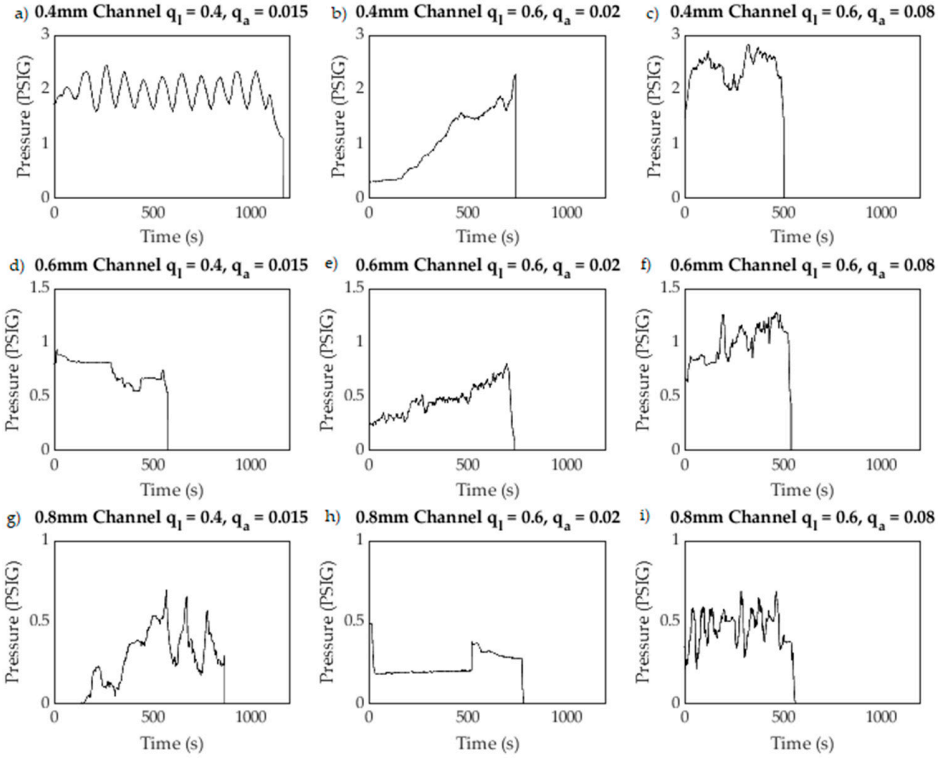


Figure S2. Pressure data obtained for each experiment of multiphase flow. (a)-(c) Results for 0.4 mm channel, (d)-(f) 0.6 mm channel, and (g)-(i) 0.8 mm channel.

3. SI. Apparent liquid holdup data for experiments

The complete liquid holdup data is reported in Figure 3. Methods for attaining this data are reported in the Methods and Materials section.

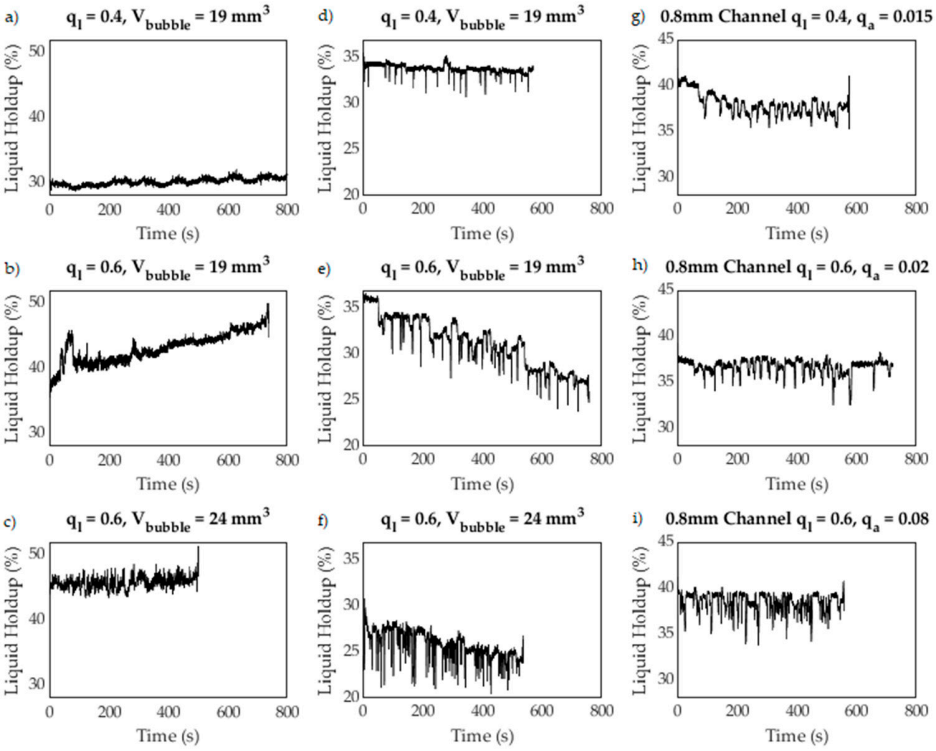


Figure S3. Apparent liquid holdup data obtained for each experiment of multiphase flow. (a)-(c) Results for 0.4 mm channel, (d)-(f) 0.6 mm channel, and (g)-(i) 0.8 mm channel.