Bernoulli theorem:

Bernoulli's principle states that an increase in the speed of the fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy.

First let's visualize what the pressure of an ideal gas (air) is.
Pressure is the number of molecules per volume at a certain temperature. Half the number of molecules inside a rigid container while maintaining the temperature constant will half the pressure inside that container.

If pressure and speed were rigidly interconnected to each other a tornado would bite its own tail and increase speed until reaching the speed of sound. In fact you would't need strong suction from air convection, just generate a micro vortex and it would grow by continuously exchanging speed for lower pressure.

Speed increase => pressure drop => speed increase => pressure drop and so forth.
Well, it doesn't work that way!

Some people seem to think that higher speed in a fluid always result in a lower pressure and then they refer to Daniel Bernoulli. Maybe if Bernoulli had said that pressure drop in a streamline gives increase in velocity, less people would have been misled.

Visualizing what pressure is, why should the number of particles per volume change just because the speed of that same volume changes? But if some of the particles in one part of the flow are accelerated before other particles in that same flow, static pressure will drop from the point where particles accelerate downstream and pressure will build up again if the accelerated particles catch up with slower moving particles in the downstream flow.

Bernoulli's theory was, and is about conservation of energy. While you can accelerate a fluid by a pressure differential force and static pressure will drop somewhere at a rate which balance the energy level of dynamic and static pressure respectively, there are other ways to accelerate a fluid, e.g. fluid (inviscid) moved by a piston in an open cylinder increase pressure when the piston speed is increased.

Se also an article by Klaus Weltner, University of Frankfurt (G) http://user.uni-frankfurt.de/~weltner/Misinterpretations of Bernoullis Law 2011 internet.pdf

More about speed and pressure here.
All fluids constitute a certain mass. A mass will not accelerate itself by exchanging pressure for speed or cause things to push it along. It takes a Force to accelerate a mass and it takes Work to

move it around. So - when fluid in a Bernoulli like pipe system (FIG. 1) is accelerating, a force must be acting on it. The force is pressure gradient or gravity, sometimes both.

In the following you will see, that the pressure buildup before the narrowing is what accelerates the fluid (higher pressure before the narrowing than after) and not the pressure drop itself. The timewise uneven acceleration of fluid particles creates the pressure drop in the narrower pipe section.

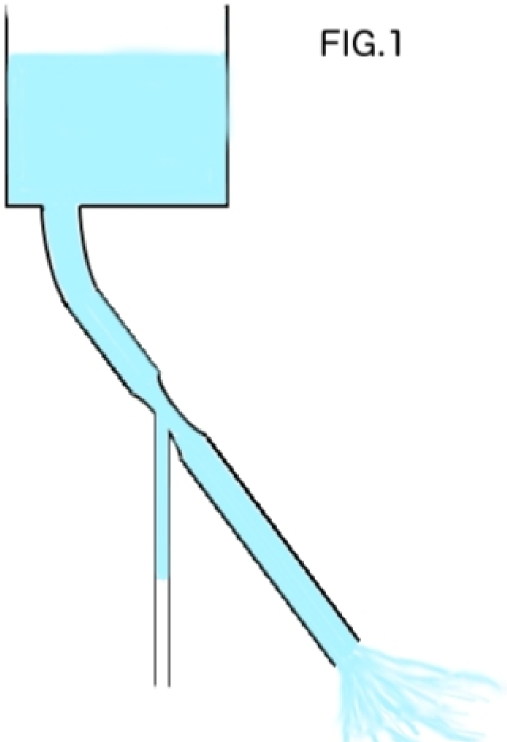

FIG.1

In a steady flow thru a pipe system the pressure gradient force is balanced by the fluid´s viscosity (simplified). If the fluid approaches a narrowing in the pipe system the fluid near the wall will alter flow vector toward the center causing a pressure build-up.
The fluid particles before the pipe narrowing is flowing in parallel, and parallel to the pipe wall. Although particles do collide in the parallel flow they don’t exchange much energy.When the tube wall start converging toward the parallel flow particles near the wall will change velocity vector both in speed and direction and particles will collide and exchange energy at a much higher rate and magnitude than in the parallel flow, creating a frictional effect. The pressure build-up before the narrowing is causing a stronger pressure gradient force compared to other sections of the pipe system and that is what accelerates the fluid.

And talking conservation of energy. Ask yourself what happens to the dynamic pressure of the particles flowing in the blue area (FIG.3), is it not converted to static pressure when they converge toward the center of the streamline and collide with particles moving with different speed and direction? Then pressure differential force caused by the exchange of dynamic pressure before the narrowing accelerates the particles after the narrowing and since all particles are not accelerated simultaneously across the cross section, pressure will drop.

Say all cars on a highway want to go from A to B as fast as possible, they start on a highway with three lanes which at some point merge into one lane. Cars pack at the narrowing bumper to bumper and after passing the jammed up area they speed up creating distance to the car behind.

Particles in the red area (FIG. 3) move at a certain speed toward the narrowing, at the narrowing particles move in from the sides and obstruct the particles free entrance to the narrow pipe, quite obvious fewer particles per volume (lower pressure) in the narrow pipe is the result. In my own words Bernoulli found out that when particles are accelerated by a pressure differential force the pressure will drop i.e. an energy exchange will take place.

FIG. 3

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