Taking a leaf out of an old book

The Poohsticks phenomenon

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Transient ischaemic attacks often have very similar, sometimes identical, characteristics. This implies that the same area of the brain is rendered ischaemic at each attack. The cause is usually an atherothromboembolism. To produce stereotypical episodes of ischaemia, such emboli must lodge in the same small artery each time. As the embolus starts from a point far from its eventual destination, how do many emboli reach the same artery?

The probable explanation is that currents and eddies in a major blood vessel are similar at different times. So, emboli released into the internal carotid artery at the same point, but at different times, might be expected to arrive at the same destination, or at least many might.

This suggestion is hard to test, but the picture is in some ways similar to what happens in a river or stream. This is how the concept of the "Poohsticks" phenomenon was derived.

No better place could be thought of to investigate this important hypothesis than at Pooh Bridge in Ashdown Forest, East Sussex. The game of Poohsticks was invented here by Winnie-the-Pooh and was first played by him and his friends Rabbit, Piglet, and Roo.[1] They collected fir cones and then, standing on one side of the bridge, each dropped a cone into the water. They ran to the other side of the bridge to wait for the cones to appear. The owner of the first cone to appear was the winner. The game is now played all over the world. Quite early on, fir cones were replaced by sticks—hence the name of the game.

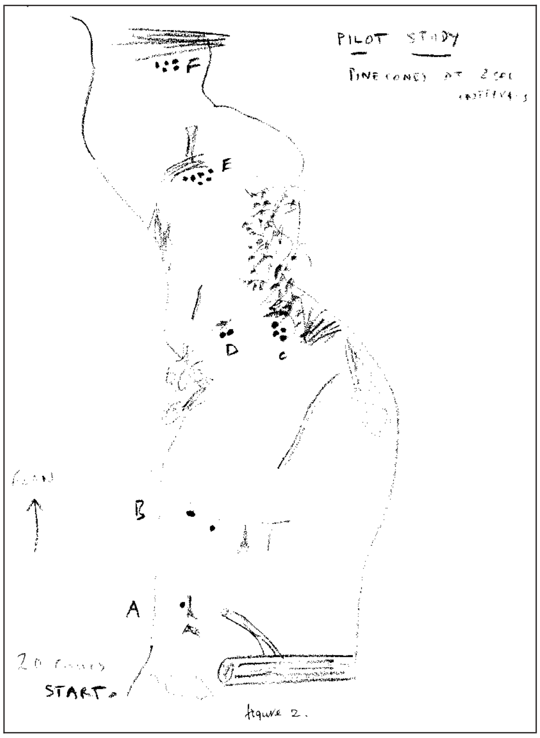

Chart showing results of test run, with A to F representing sites where cones ended up

COURTESY OF POOH CORNER, www.pooh-country.co.uk

Pooh Bridge in Ashdown Forest, where Winnie-the-Pooh—and more recently, medical researchers—played Poohsticks

Methods and results

A team of investigators from Guy's Hospital, London, assembled at Pooh Bridge. We were armed with a large supply of pine cones (chosen for their more regular shape than sticks), painted red for easy identification.

We did a test run, dropping 20 cones, at intervals of two seconds, from the same place on the bridge into the stream below. We watched their progress from the banks. Most of the cones came to rest about 200 m downstream in two distinct areas. There were three smaller clusters, and one cone got stuck early on.

A chart was drawn of the stream, and observers were stationed on the banks, close to the points where the cones had come to rest in the test run (see areas A to F on the chart). We then dropped 100 cones into the water at precisely the same point each time, at intervals of one second. Their progress was watched carefully, and we noted the places where they stopped.

Nine cones ended their journey at point A, none at B, 5 at C, 3 at D, 31 at E, and 23 at F (see chart); 29

cones were unaccounted for and were assumed to have drifted farther downstream. Thus, 31% of the cones arrived at one destination and 23% at a second. The likelihood of this happening by chance is very small ($P < 0.0001$).

Comment

Pine cones ("emboli") dropped into the stream at the same point were carried by currents and eddies downstream and ended up at a range of destinations, some of which were reached more often than others. This process is similar to what happens when emboli are released into the bloodstream. Emboli arising from a point in the heart or the aortic arch will travel to a range of destinations. Some will be swept to other parts of the body—temporarily causing minute, harmless, and unrecognised ischaemia—but others, and those from the internal carotid artery, will arrive at the brain. On the basis of the Poohsticks experiment, it is not surprising that many of them are carried to the same destination, a small artery, causing repeated ischaemia with the same clinical features.

Contributors: Rose Turner dropped the pine cones into the water. Tim Rockall drew the chart. Tim Mant, Hilary Pritchard, Eleanor Farrell, and the nursing staff of Bright Ward, Guy's Hospital, made the observations. Marion Knight painted the cones. RK conceived the study, wrote the paper, and organised the travel arrangements to Pooh Bridge; he is also the guarantor.

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1 A A Milne. *The house at Pooh Corner*. London: Methuen, 1928.

Commentary: Modelling emboli with floating fir cones

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The study by Knight draws attention to the phenomenon that repeated transient ischaemic attacks often produce similar symptoms and proposes that if the emboli are shed from the same or nearby locations, they are likely to lodge finally in the same place, thus producing ischaemia in the same region of the brain.[1]

The cones used by Knight to simulate emboli did indeed come to rest in a limited number of locations, a result that is consistent with the hypothesis proposed. Statistical analysis suggests that this aggregation was unlikely to have occurred by chance.

The river Authie and the entrance to the mill stream provide a model of the aortic arch and origin of the left common carotid artery. Note the temporary occlusive lesion

The limitations of this appealing model prompt some questions and comments. Firstly, the flow in the river, although possibly laminar, as is blood flow in most arteries, is essentially steady, whereas flow in large arteries is pulsatile, giving rise to flow patterns that vary with time. How placid or vigorous was the flow in the river and did it undergo any low frequency oscillations? If oscillations did occur, the pattern of the pine cones' arrivals at particular points might change with time; if oscillations did not occur, the cones would probably have arrived randomly at the collection points. Secondly, the vascular system consists of a many branched network in three dimensions whereas, as pointed out by a colleague (C D Bertram), floating objects inhabit a two dimensional system that can contain closed eddies. A true "flow tracer" (that is, a massless object that faithfully follows streamlines) cannot enter such a closed eddy, but one with inertia, such as a pine cone, can be impelled across the boundary. Once inside, it may have insufficient inertia to escape. Sooner or later, most paths will jostle such an inertial object into a closed eddy and the stream may provide copious eddies. Thus in two dimensions (cones floating on a stream), there is a strong likelihood of collection. However, this mechanism would not operate in the vascular system.

Turbulent flow does occur in the aorta during systole, so one might suppose that emboli arising in or passing through the heart and ascending aorta would be randomly distributed owing to the chaotic nature of such flow. However, many chaotic systems are characterised by "strange attractors," as originally described by Lorenz,[2] so emboli arising from the same place could end up in proximity in spite of the chaotic nature of the flow.

I tried to improve on the experiment by visualising flow in the river Authie (in northern France) near to the inlet of a millstream. The geometry of this junction bears a noticeable resemblance, at least in two dimensions and in certain lights, to that of the aorta and the left common carotid. A boat manned by me and three