Successful control of bleeding by closing vena cava wound with nano sheets

July 19 2013

Researchers have developed nano-adhesive plasters that can easily be applied to lacerated vessel walls with no adhesive, and succeeded in arresting massive bleeding from the inferior vena cava in rabbits.

Severe damage to the large vessels from multiple trauma or accidental complications in surgery can cause exsanguinating hemorrhage leading to death. Especially in the thin-walled vena cava abundant with blood, a tear in a small laceration soon widens, requiring a difficult and specialized vascular surgery technique to be fixed. We developed nano-adhesive plasters that can easily be applied to lacerated vessel walls with no adhesive, and succeeded in arresting massive bleeding from the inferior vena cava in rabbits.

A research group from the National Defense Medical College, in joint research with the Waseda University Graduate School of Advanced Science and Engineering, has developed nano-thickness sheets (1/100000~1/10000 mm) about the same thinness as cell membranes. These pellicle sheets are so-called "nanosheets" that can be perfectly attached, with no gaps, to the organ or tissue surfaces with no adhesive. In a world first, by applying these nanosheets, massive hemorrhaging from thin-walled large vessels such as the vena cava can be arrested. These results recently published in the *Journal of Vascular Surgery*.

Nanosheets are tightly attached to the surface of any organ and skin with no adhesive, and furthermore, cause no adhesion. Because the nanosheets are transparent, the control of the bleeding can be clearly

seen in addition to being able to overlap multiple nanosheets when there is insufficient arrest of the bleeding. A 7 mm incision to a rabbit's inferior vena cava can be fatal, but by applying nanosheets to the bleeding area, we succeeded in quick hemostasis in all the rabbits (wounds to the lungs, digestive tract and the brain's arachnoid membrane can also be simply covered by applying nanosheets). We hope that nanosheets, which can simply stop bleeding of large vessels without using complicated surgical techniques such as vascular suture, will become considerably useful for effective hemostasis not only in the surgical patients receiving major operations but also in the trauma victims with massive hemorrhage.

Research details

By making thin sheets of any substance to nano-level thickness, strong adhesive properties are put to work by the disappearance of gaps between the object where the nanosheet is applied and integrated. These are called van den Waals forces, and these are used in the nanosheets which we developed. Nanosheets are a multilayer construction of antibacterial chitosan and alginic acid, and by applying them to damaged pleura or digestive tract perforation and damaged areas of the arachnoid membrane, they function as an effective tissue seal. Furthermore, we have been able to prove the total healing of the treated area without adhesion in animal experiments. In this research, we succeeded in control bleeding without adhesion by applying nanosheets to injuries in large venous vessels which are difficult to be repaired.

Research results

We have developed nano-thickness sheets (1/100000~1/10000mm), about the same thinness as cell membranes, in joint research between the National Defense Medical College and Waseda University Graduate

School of Advanced Science and Engineering. These pellicle sheets are so-called "nanosheets" that can be perfectly attached, with no gaps, to the organ or tissue surfaces with no adhesive. In a world first, by simply applying nanosheets to large wounds to the delicate walls of large venous vessels such as the vena cava, which, up until now, have required suturing technique in vascular surgery, we succeeded in controlling bleeding (effective hemostasis?) without adhesion. These results will be published in the Journal of Vascular Surgery (May 17 online version, and in print in the June Vol. 1 No. 3 version).

Severe damage to large venous vessels from multiple trauma or accidental complications from surgery can cause massive bleeding resulting in death. Especially in the thin-walled vena cava abundant with blood, a tear in a small laceration soon widens, requiring a difficult and specialized technique of vascular surgery to be fixed. We made a model of massive bleeding by making a 7 mm incision in the inferior vena cava of a rabbit, and succeeded in closing the cut and achieving a complete hemostasis by applying nanosheets to the opening. We succeeded in hemorrhage arrest through application of the nanosheets in all tests, and there was no apparent deformity to the treated area such as constriction and aneurysms, or adhesion. Even if slight bleeding remains after nanosheet application, bleeding was completely arrested by multi-overlapping. We expect that nanosheets, where application only can easily control and stop bleeding in injuries to large vessels will be useful in sudden vascular injuries such as multiple trauma. In the future, through improvements, we aim to develop nanosheets which are also effective controlling arterial bleedings.

More information: *Journal of Vascular Surgery* (May 17 online version, and in print in the June Vol. 1 No. 3 version).