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XXXIV. *Further Remarks on the Properties of the Coagulable Lymph; on the ſtopping of Hæmorrhages; and on the Effects of Cold upon the Blood: By* the ſame.

Read Nov. 22, and Dec. 6, 1770.

IT has been obſerved by thoſe who have written on the blood, that it ſometimes happens in blood-letting, that the firſt cup has an inflammatory cruſt, whilſt the laſt has none; but no ſatisfactory reaſon has been given for this appearance. One might ſuppoſe that it was owing to a difference in ſome circumſtance in the operation, ſuch as in the velocity with which the blood flowed into each cup, or by the latter being agitated ſo as to prevent the ſeparation of the lymph: but I have ſeen it where there was no difference of this ſort, nor in any other circumſtance that I could obſerve. I have therefore ſuſpected that in ſuch caſes the properties of the blood are changed, even during the time of the evacuation; and in this opinion I am confirmed by the following experiments.

Experiment XIX.

Nine ounces of blood were taken from a woman who had been delivered two days before, and who at

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that time laboured under a fever, with a conſiderable pain in her ſide, and in her *abdomen*. The blood was received into a baſon, and her arm was tied up; when, on looking at the blood, I found its ſurface tranſparent for ſome depth, an indication of a future cruſt; and as her pain was not abated, and her pulſe bore it well, I removed the ligature from her arm, and took away about ſix ounces more, into three tea-cups; but what appeared to me remarkable, although the blood flowed as faſt into each of the cups as into the baſon, and they were ſet down immediately when filled on the ſame window, yet there was no inflammatory cruſt on that in the cups, though a very denſe one on that in the baſon. And again, although that in the baſon was taken away ſome minutes before that in the cups, yet it was later in being completely coagulated; as was evident on comparing them.

I had an opportunity of repeating the experiment in the evening; for her ſymptoms of inflammation ſeeming equally violent, it was thought proper by the phyſicians who attended her, to take away more blood; which was done by opening the ſame orifice, when three tea-cups were nearly filled, and ſet in the ſame place; and it was obſerved, that the firſt had a cruſt, though not ſo thick a one as in the firſt operation; but the other two cups were without this appearance, though the blood had flowed into them even more quickly than into the firſt.

Experiment XX.

A gentleman, who laboured under an inflammatory complaint, had about nine ounces of blood taken from

from his arm. This quantity was divided into four portions; the firſt was received in a cup, and was in meaſure little more than an ounce; the ſecond, in a baſon, to the quantity of two ounces; the third, in a cup, which held one ounce; and the fourth, in a baſon, to the quantity of three ounces. Each veſſel was placed immediately upon the window; and it was obſerved that the blood in the firſt was lateſt in coagulating, and had a cruſt over the whole ſurface; that in the ſecond, had a cruſt only upon a part of its ſurface; but that in the third and fourth had no cruſt, and manifeſtly coagulated before either of the other two.

From theſe experiments it is evident, that the properties of the coagulable lymph can be ſoon changed; ſince, in the ſpace of three or four minutes, the diſpoſition to coagulate was increaſed, and probably too the lymph was thickened. It might indeed, at firſt ſight, ſeem poſſible, that blood-letting had only let out the vitiated part; but this is highly improbable; for, ſuppoſe a part only of the blood was vitiated, that part muſt have been equally diffuſed through the whole maſs, and there is no likelihood of its getting out of the veſſels before the reſt of the blood; and conſequently it ought to have appeared in the laſt equally as in the firſt cup, but it did not. Bleeding, therefore, in thoſe caſes alters the nature of the blood, not by removing the vitiated part, and giving room for new blood to be formed, as has been ſuſpected; but probably by changing that ſtate of the blood-veſſels on which the thinneſs, and leſſened tendency of the lymph to coagulation, depends; which ſurely is a very curious circumſtance. This

fact

fact is the more remarkable, ſince it ſhews the improbability of the opinions of thoſe who maintain that this vitiated blood is the cauſe of the diſeaſe, ſince the diſeaſe remained, though the properties of the blood were changed *.

From this obſervation we may be led to think, that it may be uſeful to receive the blood more frequently into ſmall cups, inſtead of a baſon, and to attend more carefully to the alteration produced upon it by bleeding; as we may by that means perhaps learn to determine better, what quantities ſhould be taken away in particular caſes. For it would ſeem probable that the operation is likely to have the moſt effect on the diſeaſe, in thoſe caſes where the greateſt change is produced by its means, on the diſpoſition of the blood to coagulate; and of that change, we can judge, by comparing the blood in the firſt cup, with that in the laſt; for the firſt cup will nearly ſhew the ſtate of the blood at the beginning; and the laſt cup the ſtate of the blood at the latter part of the evacuation.

It frequently happens, that inſtead of an inflammatory cruſt over the whole ſurface of the *craſſamentum*, there is only a partial one, which appears in large ſpots or ſtreaks. In ſuch caſes I have obſerved, that

* That the properties of the blood can be changed by emptying the blood-veſſels, is likewiſe proved by an experiment hereafter to be related; where the blood in an animal in health was found to have its diſpoſition to coagulation increaſed, in proportion as the veſſels were emptied, and as the animal became weaker. It may likewiſe be neceſſary to mention, that though the inference is here drawn from two experiments only, yet I have likewiſe obſerved the ſame appearance in other caſes, which I have thought it unneceſſary to relate.

only a part of the blood had its diſpoſition to coagulate leſſened, as in experiment XV. in which ſome of the blood remained fluid and tranſparent, where thoſe ſtreaks appeared, for ſome time after the coagulation had begun in other parts of the ſurface. Now whether in thoſe caſes there had been the ſame difference before the vein was opened, or whether the whole blood had not been of the inflammatory kind, before veneſection, and a part of it was changed as it ran out, or as ſoon as the general fulneſs was diminiſhed, may be a queſtion; but the probability, I think, is much in favour of its being changed during the time of the evacuation, from what was obſerved in the laſt related experiments.

When I had obſerved that this diſpoſition of the lymph to coagulate was increaſed by bleeding, or by weakening the action of the blood-veſſels, it occurred to me, that poſſibly in thoſe caſes where the body was very weak, the diſpoſition to coagulate might be ſo much increaſed, that inſtead of being three or four minutes in beginning to do it, after it is let out of the veins (as is the caſe in people in health) it might coagulate in leſs time, or almoſt inſtantaneouſly; for I imagined, that unleſs this took place, we could hardly conceive how the blood ſhould ever have time to coagulate in ruptured veſſels, ſo as to ſtop hæmorrhages, as it is believed to do. And upon this occaſion I recollected an obſervation of Dr. Hunter's, which is "that the faintneſs which comes "on after hæmorrhages, inſtead of alarming the by-"ſtanders, and making them ſupport the patient by "ſtimulating medicines, as ſpirits of hartſhorn and "cordials, ſhould be looked upon as ſalutary; as it

"ſeems

" ſeems to be the method nature takes to give " the blood time to coagulate!" As this obſervation ſeemed to favour my ſuſpicion, I determined to make the experiment.

Experiment XXI.

Believing it would be ſufficient for this purpoſe, to attend to the properties of the blood, as it flows at different times from an animal that is bleeding to death, I therefore went to the markets, and attended the killing of ſheep; and having received the blood into cups, I found my notion verified. For I obſerved, that the blood, which came from the veſſels immediately on withdrawing the knife, was about two minutes in beginning to coagulate; and that the blood taken later, or as the animal became weaker, coagulated in leſs and leſs time; till at laſt, when the animal became very weak, the blood, though quite fluid as it came from the veſſels, yet had hardly been received into the cup before it congealed. I have alſo varied the experiment, by receiving blood into different cups at different times, whilſt the animal was bleeding to death; and though the time taken up in killing the animal was not commonly more than two minutes, yet I obſerved, on comparing the cups, that the blood which iſſued laſt coagulated firſt. I have obſerved likewiſe, that the blood coagulates with a different appearance in proportion as the animal becomes weaker; that which follows the knife begins to coagulate in about two minutes; it firſt forms a film or pellicle on the ſurface, which extends gradually through the whole

blood, yet ſo ſlowly that its progreſs may be obſerved, eſpecially if the pellicle be moved from time to time. But the blood that flows from the fainting animal is coagulated in an inſtant, after it once begins. From this obſervation, that the diſpoſition of the blood to coagulate is increaſed as the animal becomes weaker, we may draw an inference of ſome uſe with regard to the ſtopping of hæmorrhages, viz. not to rouze the patient by ſtimulating medicines, or by motion, but to let that languor or faintneſs continue, ſince it is ſo favourable for that purpoſe; and alſo, that the medicines likely to be of ſervice in thoſe caſes, are ſuch as cool the body, leſſen the force of the circulation, and promote that languor or faintneſs *. For in proprtion as theſe effects are produced, the divided arteries become more capable of contracting, and the blood more readily coagulates; two

* Beſides giving ſtimulants and cordials to counteract the fainting, it is a common practice in many parts of England, to give women, who are flooding, conſiderable quantities of port-wine, on a ſuppoſition that it will do them ſervice by its aſtringency. But ſurely, from its increaſing the force of the circulation, it muſt be prejudicial in thoſe caſes. Perhaps many of the remedies called ſtyptics might be objected to for the ſame reaſon.

It has of late been proved by experiments, particularly by thoſe of the ingenious Mr. Kirkland, that the larger arteries, when divided, contract ſo as to ſtop the hæmorrhage. But the large *coagula* which we ſee in the orifices of the veſſels of the *uterus* of thoſe who die ſoon after delivery, and the ſtopping of hæmorrhages where the blood veſſels were ruptured on their ſides and not entirely divided, makes me believe that contracting the bleeding orifice is not the only method nature takes to ſtop an

circumſtances that ſeem to concur in cloſing the bleeding orifices.

It has been queſtioned whether blood-letting can be properly recommended in hæmorrhages, excepting in thoſe that are attended with evident ſigns of *plethora:* but do not theſe experiments ſhew, that a vein may be opened with propriety, even where there is no *plethora,* in order ſuddenly to bring on weakneſs; by which the momentum of the blood may be ſo diminiſhed, and the diſpoſition of the lymph to coagulate may be ſo increaſed, as to ſtop the hæmorrhage? For, when we conſider how ſoon the blood-veſſels contract, and adapt themſelves to the quantity of blood which they contain, it ſeems not improbable that in ſome caſes where the hæmorrhage is not profuſe, but long-continued, the ſtrength of the patient may be ſo recruited, that the diſpoſition to coagulate ſhall not be ſufficiently increaſed, or the extremities of the veſſels ſufficiently contracted, for the ſtopping of the bleeding; but, by emptying the veſſels ſuddenly, this effect may be produced, and the hæmorrhage may be ſtopt by the loſs of leſs blood, than would have happened, had only the ſlow draining been continued.

Although the whitiſh cruſt is ſo commonly ſeen in inflammatory diſorders, and has ſo very morbid an appearance, as might induce us to conſider it as inflammatory, and to bleed repeatedly in all thoſe caſes where it occurs, yet I believe we ſhould act improperly: for, to ſay nothing of pregnancy, in

hæmorrhage. Her reſources indeed are great, and ſhe has often more methods than one of producing the ſame effect.

which

which the appearance is almoſt conſtant, there are few phyſicians that have not ſeen patients, who, even in ſuch circumſtances, have been the worſe for this evacuation. Nor need we be ſurpriſed that this ſhould happen, conſidering how ſoon in ſome inſtances this ſize diſappears; and if ſo, may we not ſuppoſe, that it may likewiſe ſoon be formed, even by a ſhort exertion of ſtrength in the veſſels? Perhaps this was the caſe in the gentleman mentioned in page 399, who, in leſs than twenty-four hours after bleeding, had ſymptoms of great weakneſs.

As it appears from the above related experiments, that the diſpoſition of the blood to coagulate is increaſed by bleeding, it may perhaps be uſeful to attend to this circumſtance, and to compare the coagulation of the blood in the laſt, with that in the firſt cup, even in caſes that are not attended with the inflammatory cruſt. And it may likewiſe be worth while to make the ſame compariſon in thoſe caſes where every cup has a cruſt; which frequently happens in rheumatic, and likewiſe in phthiſical complaints. By theſe means we may judge what effect the evacuation has produced on the ſtrength or fulneſs of the veſſels; and may perhaps, by attending to the laſt cup, if it contain only a ſmall quantity, be able to gueſs pretty nearly at the nature of the blood which remains in the body. In the rheumatic caſe mentioned in page 391, every cup contained this cruſt; and although the blood in the laſt cup coagulated in much leſs time than that in the firſt, yet as it was later in coagulating than common. I ſuſpected what remained in the veſſels had the ſame

diſpoſition; but the patient got well without repeating the evacuation.

It may be mentioned here, that I have once or twice ſeen blood, which, when it firſt began to coagulate, had on its ſurface a red pellicle, and underneath a tranſparent fluid, which afterwards formed a cruſt. In theſe caſes, if the red pellicle had not been removed before the reſt of the blood had congealed, we might have concluded that no part of the blood had this diſpoſition to form a white cruſt. This appearance, I ſhould imagine, was owing to the blood, where in contact with the air, having coagulated very early, and therefore before the red particles had time to ſubſide, from that part of the lymph which had its diſpoſition to coagulation leſſened.

The learned profeſſor de Haen has taken notice of a curious appearance of the blood, which he could not account for; but which, I preſume, may be explained from ſome of the above experiments. His obſervation is, "That, having bled a perſon in a fever, "the blood was covered with an inflammatory cruſt, "and upon examining the *craſſamentum* in one of "the cups, it formed a ſort of ſack containing a "clear fluid: this fluid being let out, and the whole "covered and ſet by, on examining it next morning, "a very firm cruſt covered the whole again, and "extended to the bottom of the cup*." I once met with a caſe ſimilar to this; for, having bled a perſon into four cups at ten o'clock in the morning, on looking at the blood afterwards, at five in the afternoon, I found the *ſerum* had not ſeparated from the *craſſamentum* in the firſt cup; but the

* Vide Rat. Medendi, cap. vi.

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craſſamentum felt as if it contained a fluid in a bag, as profeſſor de Haen has deſcribed it. Upon preſſing it, the fluid guſhed out, which, in a few minutes after being expoſed to the air, coagulated: there was however this difference in the two caſes, that in mine the fluid was red, ſo that it formed a red cruſt over the firſt, which was white. Now this ſeems to have been owing to the blood's having firſt coagulated, where it was in contact with the air and with the ſides of the cup; and the fluid which guſhed out was the *ſerum*, with a part of the coagulable lymph, which yet remained fluid; but, when expoſed to the air, jellied or coagulated, as it naturally does. That one part of the lymph can remain fluid after the other is coagulated, is proved by ſome of the preceding experiments; and I have more than once ſeen blood, which appeared perfectly jellied ſoon after bleeding; yet, on cutting into the *coagulum*, a tranſparent fluid has ouzed out, which afterwards jellied. And ſo ſlowly does this coagulation proceed in ſome caſes, that, in an experiment mentioned before, a part of the blood in a dog's heart was found uncoagulated thirteen hours after death. And I have likewiſe diſtinctly obſerved, that in ſome caſes where the diſpoſition to coagulate was much leſſened during the evacuation, the blood at the bottom of the cup has jellied, whilſt the greateſt part of the *ſize* at the top was yet fluid; there being only a thin pellicle on its ſurface, where it was in contact with the air.

Another inſtance of a change in the properties of this coagulable lymph, which appears curious, was obſerved in ſome experiments, where I had occaſion to

to throw the blood into water, and oil, during the winter ſeaſon whilſt the heat of the water and oil was no higher than 41° of Fahrenheit's ſcale. In all thoſe experiments, I found that the diſpoſition to coagulate was leſſened, the blood becoming more and more viſcid, but did not coagulate whilſt in that degree of cold. I ſhall next relate thoſe experiments.

Experiment XXII.

The jugular vein being cut out from a rabbit juſt killed, was thrown into water of 41° of heat, and taken out at the end of half an hour; when the blood was found to be ſtill fluid, though rather more viſcid than natural; but, after being expoſed to the air for a few minutes, it coagulated.

Experiment XXIII.

Two pieces of the jugular vein of a dog, juſt killed, were put into water, in which the thermometer ſtood at 41°; one was taken out after twenty minutes, and the other after three quarters of an hour; the blood in both was found to be fluid, and to coagulate afterwards.

As it was evident, from theſe experiments, that the water had leſſened the diſpoſition of the blood to coagulate, I next enquired to what property in the water this effect could be owing; and to ſee whether water that was warmer would not have the ſame effect, I made the following experiment.

Experiment XXIV.

On December the thirteenth, I cut out two pieces of the jugular vein of another dog, immediately after his death. One piece was put into cold water, and the other into water kept warm by a lamp, ſo that the heat never varied more than between 90 and 100°. At the end of three quarters of an hour, that in the warm water had in it a coagulum as large as a garden pea; but that in the cold water, on being let out into a cup, was found to be quite fluid. Twenty minutes after being expoſed to the air, that which had been in the cold water was coagulating; but that from the warm water neither then nor afterwards ſhewed any ſigns of farther coagulation: ſo that it ſeemed not only to have jellied whilſt in warm water, but to have begun to part with its *ſerum*. From this experiment, it ſeems probable that the *coldneſs* was that property of the water to which the leſſened diſpoſition to coagulate was owing; but, to be more ſure of this, and to ſee whether the blood might not be kept fluid a longer time by theſe means, I tried as follows.

Experiment XXV.

On January the fourteenth, I cut out a piece of the jugular vien of another dog, and put it into oil, in which the thermometer ſtood at 38°. At the end of ſix hours it was taken out, and the red particles were obſerved through the coats of the vein to have in great meaſure ſettled to one ſide.

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The blood was let out into a cup, and was found to be fluid; at the end of fifteen minutes above one half was ſtill fluid; in twenty-five minutes it ſeemed to be quite jellied. Now as in this experiment a ſimilar effect was produced, as when the vein was put into water, it ſeems probable that it was the coldneſs of the water, and of the oil, which had leſſened the diſpoſition of the lymph to coagulate.

Experiment XXVI.

Another piece of the ſame vein was put into river-water, in which the thermometer ſtood at 38°, and was left till the next morning; when, after twenty-two hours and a quarter, it was taken out. The particles did not ſeem to have ſubſided, as in the former experiment; but the vein being opened the blood was found to be fluid, though ſo viſcid that it could barely drop from the vein. The cup into which it was received was placed upon the window of a moderately warm room, and was examined carefully from time to time; but the blood never had any appearance of coagulation, but remained fluid till it was dried by the evaporation of its water, which happened by the next day. In this experiment the cold ſeemed intirely to have prevented the coagulation of the lymph: ſo ill-founded is the common opinion, that cold coagulates the blood.

As the lymph can be deprived of its power of coagulating, on being expoſed to the air, by ſo ſlight a circumſtance, as it would ſeem, as the cooling it ſuddenly; it is the leſs to be wondered at, that ſuch a change ſhould ſometimes take place in the blood-

veſſels of a living body; an inſtance of which, I have been told, was obſerved by the learned profeſſor Cullen, who having ordered an epileptic patient to be bled, the blood was found not to coagulate; but, on bleeding him the day following, the blood coagulated, as uſual. A ſimilar inſtance, I ſaw lately, by the favour of the medical gentlemen of the Britiſh Lying-in-Hoſpital, who, having bled a woman in a fever that came on ſoon after delivery, the blood was found not to coagulate on being expoſed to the air, but appeared like a mixture of the red particles and ſerum only; the particles having ſubſided to the bottom, in the form of a powder. She died three days afterwards; and, upon opening her, we found the blood had coagulated in her veſſels after death; and that a denſe white *polypus* was formed in each auricle of her heart; one of which, I have now by me. I examined the blood taken away before ſhe died, and found on expoſing it to heat, that it did not coagulate ſooner than *ſerum* commonly does, or under 160°: ſo that it is probable, that at the time ſhe was bled, her blood either was without the coagulable lymph, or that its properties were changed.

After a blow or contuſion, the blood now and then burſts from the blood-veſſels into the cellular membrane, ſometimes forming an *ecchymoſis*, and ſometimes a tumor; and it is a queſtion with ſome, whether that blood coagulates or not; but that it coagulates in moſt of theſe caſes, is proved by the opening of ſuch tumors. Yet it has likewiſe been obſerved, that now and then theſe tumors have been attended with a fluctuation, and after ſome time their contents have been abſorbed: and it has alſo been found upon opening

opening ſome of them, even ſeveral weeks after the accident, that the blood was fluid. In ſuch caſes the blood had probably undergone a change ſimilar to what was obſerved to take place in ſome of the preceding experiments; that is, the lymph had been deprived of its property of coagulating, in paſſing from the blood-veſſels into the tumor.