An address on blood pressure in man : its estimation and indications for treatment : delivered before the Westminster Division of the British Medical Association / by Sir Lauder Brunton.

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An Address

ON

BLOOD PRESSURE IN MAN:

ITS ESTIMATION AND INDICATIONS FOR TREATMENT.

DELIVERED BEFORE THE WESTMINSTER DIVISION OF THE BRITISH MEDICAL ASSOCIATION.

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MR. PRESIDENT AND GENTLEMEN,—The measurement of blood pressure in man is a subject in which I have taken a great interest for more than forty years, partly on its own account and partly because I have been fortunate enough to reckon amongst my personal friends many of the pioneers of this kind of research: Ludwig, Marey, von Basch, Burdon-Sanderson, Gamgee, Kronecker, Mosso, and Oliver. The circulation of the blood is kept up by the pumping action of the heart, but during the intervals between each stroke of the ventricle, intervals which amount to about thirteen hours out of the twenty-four, the circulation is maintained by the arterial tension, which depends on the difference between the amount of the blood pumped into the aorta and that leaving the arterial system through the capillaries in a given time. Its height will necessarily vary with the increased or diminished action of the heart and with the increased or diminished resistance presented by the arterioles or capillaries to the outflow of blood into the veins.

The ordinary method of ascertaining blood pressure is to put three fingers upon the radial pulse. The finger nearest the hand prevents the recurrent pulse through the palmar arch, the middle finger feels the pulse, and the finger nearest the heart compresses the artery until the middle finger can no longer feel the pulse. The tension is estimated by the greater or less amount of pressure required to extinguish the pulse. Much information can be gained in this way, but the chances of error are considerable, even to an experienced observer, and no definite information as to the exact tension can be con-

veyed from one person to another; in other words, no record of the tension can be kept. The difference between estimating the tension by merely feeling with the finger and by an exact instrument is about the same as that between estimating the temperature by feeling the skin and using a thermometer.

The simplest instrument for measuring blood pressure was a modified spring balance with a little knob, by which the artery could be compressed, and the tension was then read off on a scale. This, however, proved unsatisfactory, and a great improvement upon it was the replacement of the solid knob by an elastic pad filled either with air or fluid. Although very useful conclusions regarding blood pressure in man could be drawn from observations with Marey's sphygmograph, and such observations enabled me in 1867 to use nitrite of amyl with success in lowering the tension, yet the first actual measurement of blood pressure in practice was made by von Basch. At a meeting of the Physiological Society in Berlin he showed that when an elastic pad was connected with a mercurial manometer and placed upon one femoral artery in a dog it stopped the circulation in it when the pressure was equal to that indicated by another mercurial manometer connected with the interior of the other femoral.

The apparatus which he used clinically consisted of a mercurial manometer, the bulb of which was surrounded by water and rested like a pad upon the artery. This could be pressed down by means of a screw until the circulation in the distal part of the artery was obliterated, as was shown by the movements of a small sphygmograph placed upon it. The difficulty of using a mercurial manometer induced him to replace it by an aneroid. To this an india-rubber ball filled with air was attached, and it was used by pressing the india-rubber ball upon the radial artery until the pulse was obliterated. The pressure was then read off on the dial of the aneroid. This instrument is often described as Potain's, but the only difference between the two is that while the latest form of von Basch's bulb consisted of a metallic ring, the openings of which were covered by india-rubber of different thicknesses, the metal ring was replaced in Potain's by thicker rubber, so that the whole bulb was made of rubber of different thicknesses.* This still forms one of the most convenient instruments for measuring blood pressure, but in order to get satisfactory results certain precautions require to be adopted. The first of these is to have the bulb over the lower end of the radius, so that the artery can be compressed between the bulb and the bone. If the bulb is placed higher up, the resistance afforded by the underlying tissues is insufficient, and too high a reading is obtained. The second precaution is to apply the pressure on the bulb perpendicularly to the face of the radius. If the pressure is applied obliquely, too high a reading is again obtained. The third is to prevent recurrent pulsa-

* In the latest form supplied by Messrs. Down Bros. the bulb is of rubber having the same thickness throughout

tion through the palmar arch. If the vessels are much dilated the blood from the ulnar artery flows so freely through the palmar arch that pulsation may be readily felt in the distal end of the radial, although the part lying over the radius has been completely obliterated by pressure. In order to prevent this error, the palpating finger should be placed over the distal end of the artery with its tip towards the bulb. The recurrent pulsation from the ulnar artery is prevented by the pressure of the pulp of the finger, while the direct pulsation from the radial artery is perceived by the tip. In Oliver's instrument the artery is also compressed by a bulb containing fluid, but the pressure is transmitted by a rod to a spring, which indicates the pressure on a dial instead of being transmitted by a tube containing air to an aneroid barometer. In Hill and Barnard's small instrument the pressure is also made by an india-rubber bag containing air, but this bag is larger, and the pressure is indicated by a column of fluid working against the compressed air. Each of these has its own advantages, but the one that I personally prefer is Potain's modification of von Basch's instrument.

Besides the risk of mistake from imperfect application, however, this instrument possesses another disadvantage, namely, that by use it may cease to give correct measurements. It is, therefore, almost necessary to have at home a mercurial manometer with which the aneroid may be compared from time to time. This, however, is very easily done by simply connecting both of them at the same time with a bulb which can be squeezed so as to raise the pressure equally in both. The deviation of the aneroid from the true pressure can thus be readily ascertained and noted down, and the correction made as required. This is no more trouble than using a thermometer with a Kew correction.

A second class of instruments for taking blood pressure consists of those in which a finger or arm is compressed by a distensible india-rubber bag outside of which lies an unyielding ring or band. Mosso's sphygmomanometer is an example.* Gaertner's tonometer is also one of this class, and it has the advantage of being easily applied to the finger. Rings of various sizes are supplied, and a finger is passed into one which fits it fairly. The blood is then pressed back from the end of the finger by winding a strip of elastic round it, or by pushing over it a small, strong india-rubber ring. By means of a bulb which communicates both with the ring and with a manometer, air is blown in until the pressure is sufficiently high to stop the circulation in the finger. The elastic band, or the india-rubber ring by which the blood was driven out, is then removed, the pressure is then gradually relaxed until the finger flushes, and the height at which the

* It was by means of Mosso's instrument that Tunnicliffe and I showed that the blood pressure in man is raised during exertion, but falls after exertion is over (BRITISH MEDICAL JOURNAL, October 16th, 1897).

mercury stands in the manometer is then noted. This gives the tension at which the blood within the vessel can overcome external pressure. The objections to this instrument are the trouble it takes to empty the finger of blood and the difficulty there sometimes is of being quite sure of the moment when the blood returns to it.

In another subdivision of band apparatus the pressure is applied to the forearm or arm by an india-rubber bag encircled by a broad unyielding band. The air is blown into this until the pulse at the wrist can no longer be distinguished, and the pressure is then read off either from a mercurial or aneroid manometer, which is also connected with the bulb by which air is pumped into the armlet. Two of the most convenient forms of this apparatus are Martin's and Lockhart Mummery's. In Martin's the manometer is formed by a U tube containing mercury; in Lockhart Mummery's by a somewhat wide cistern from which a graduated tube rises. In Martin's the mercury descends in one leg of the tube as it rises in the other, and the actual height of the mercurial column depends on its rise above the zero point in the ascending column *plus* its fall below the zero point in the descending one. If both tubes are of equal calibre the height of the column will be exactly given by doubling the rise above the zero point; but if the two tubes are of unequal size, doubling the rise above zero may give a very inaccurate reading indeed, and each manometer ought to have a scale made expressly for itself. We can see the effect of inequality between the size of the two limbs in Lockhart Mummery's, where the cistern which constitutes the descending limb is so wide that the fall in it is almost negligible, and if we were to double the rise above zero in the ascending limb as we did in Martin's we would get very nearly twice the true measure. The disadvantage of the band apparatus is that, although it may be used above the dress, yet it is better to have the arm exposed, and this is troublesome. It also causes discomfort in the hand and arm, and sometimes even pain, which makes nervous and sensitive ladies dislike it. The advantage is that it is less liable to give a wrong reading through imperfect application, and its indications are therefore generally much more trustworthy than those obtained by simple pressure bulbs. Instead of a mercurial manometer the pressure may be estimated by a column of coloured liquid working against the compressed air, as in Oliver's apparatus, or by an aneroid. The latter, I find, is the most convenient form.

The band apparatus is often known by the name of the Riva-Rocci, as he first introduced the method, although it has been considerably modified by others—Hill and Barnard, Martin, Mummery, and many others. Its indications are upon the whole, as I have said, more trustworthy than those of von Basch's, but the latter apparatus is so easy to use that if we employ half a minute to count the pulse we can ascertain the tension easily in half a minute more without any trouble to the patient. We

can therefore use it in every case and reserve the band apparatus for those cases in which special accuracy is required. The indications given by the band and by the bulb are, as a rule, fairly alike, but it has seemed to me that in very stout patients the band apparatus sometimes gives a higher reading than the bulb. Stiffness of the arteries from atheroma is said to be a serious drawback to the accuracy of the indication either to bands or by bulbs. I think that if either the band or the bulb is placed over a bit of stiff artery an error very probably does result, but this can be got over to a considerable extent by using the bulb on both wrists and the band on both arms in all doubtful cases and taking the lowest reading if there is any difference. It is not likely that all the arteries will be so stiffened as to prevent a fairly approximative reading being obtained. A short time ago, on feeling the pulse of a man aged 76, I was struck with the rigidity of the left radial. The tension in it with von Basch's apparatus was 170, and the right radial was only 150, but in both arms with the band apparatus I got a reading of 155.

According to my own observations the average tension is from 100 to 120 in young men, in middle age 125 to 135, and above 60 it may rise to about 145 or 150, but even in men between 60 and 70 the tension may remain at 125 or 130. In women I think the tension is usually 10 to 20 mm. lower.

The cases in which I find a low tension below 100 in men and 80 or 90 in women, are generally (1) weakness after some illness, and more especially after influenza; (2) in cases of commencing phthisis; and (3) in heavy smokers.

High tension is apt to come on with advancing years and thickened arteries, more especially in gouty people, and where the kidneys are contracted the tension may rise very high. The common indications of this condition usually are (1) rising in the night to pass water, (2) the urine being of low specific gravity and often containing a very minute trace of albumen, so small that it is apt to escape notice unless the urine be acidulated with acetic acid and only the top of the test tube boiled so that the lower part remains for comparison. On then looking at the top against a dark background a faint haze may often be observed. This usually becomes still more distinct on the subsequent addition of picric acid.

The feelings of a patient which accompany high or low tension vary considerably in different individuals. Some appear to work easily and well with a tension of 100, while others are depressed, languid, and easily fatigued. On the other hand, a tension of 160 to 170 may be unaccompanied by discomfort of any kind and some patients appear perfectly well, while in others this tension may be accompanied by palpitation, precordial pain, or dyspnoea on exertion. Tension of 180 or 190 is, I think, of very serious import, but I have known one patient continue for several years with a tension which was rarely below 180, and sometimes rose to 200, or even higher. She had occasionally small cerebral haemorrhages, but died in the end apparently of cardiac failure after an acci-

dental fall. In all the cases I have seen, excepting one, tension approaching 300 has been quickly followed by a fatal issue. As a general rule I look upon any tension over 150 as indicating the advisability of limiting proteids in the patient's dietary. In regard to the indications for treatment, I consider that when the tension is down to 80 or 90 absolute rest in bed is usually required with nutritious diet, beef-tea, and cardiac tonics and stimulants, such as strophanthus, caffeine, nux vomica or strychnine; gentle massage and graduated exercises in bed may also be employed. As the cardiac muscle is feeble, iron in some form should be given if it can be tolerated. Occasionally complete rest may be absolutely necessary with a tension of 100 to 110 mm., because even with this tension one occasionally meets with symptoms of syncope in the upright position, and, on the other hand, the tension may be as low as 90 in cases of commencing phthisis without any indication of anything being wrong with the circulation. Low tension is therefore not to be regarded as an absolute indication for treatment any more than a very quick or a very slow pulse, but it must be taken along with other factors in determining the patient's condition and the necessary treatment. Low tension after influenza requires, I think, great care, because influenza and diphtheria seem to have a power of weakening the cardiac muscle almost more than any other disease. Cardiac weakness after enteric fever is very common, but there is less risk of damage to the heart from it, because the convalescence is long and the heart has time to recover. In influenza the patient often resumes work after the acute symptoms are over, and I frequently have patients complaining of symptoms of cardiac weakness for some years after influenza, in one case as much as eight years. It is, I think, more especially in slight cases of influenza that the risk of cardiac overstrain occurs, and great care is therefore necessary not to overlook such cases. In them tonics, open air, and exercise without strain are what are generally indicated.

But it is in cases of high tension that the sphygmomanometer is especially useful. Like the storm signal at a seaside port, it gives timely warning of dangers to come. In many men above middle age high tension is associated with extraordinarily great and untiring energy, and it is curious to note how often cases are recorded of sudden death where the patient has remarked a few hours before that he never felt so well in his life. In many cases of men above 55 or 60 we find a systolic murmur over the aorta indicating atheroma, with an accentuated second sound indicating high tension. In some the mitral valve begins to yield, and a systolic murmur becomes audible at the apex. When this is the case the tension does not rise so high, and I think that a leaking mitral in such cases, like a leaking tricuspid, is really a safety valve for the high tension, which tends to prevent either cardiac failure or cerebral haemorrhage and adds considerably to the life of the patient. In such cases

where the tension is over 150 the proteid diet should be much limited, and the use of tea, coffee, and alcohol restricted, although it may not be necessary to interdict them completely. The great things to avoid are *hurry* and *worry*. Both of these are specially difficult to avoid, because patients with high tension are frequently—perhaps I may say generally—very energetic, and if anything is to be done they wish it carried through with the least possible delay, and are apt to do it themselves rather than wait for any one else. They often ask whether they may take exercise, and it is well to explain to them that it is not the length of time during which they take exercise that is dangerous, but the amount of strain at any one moment. They may often walk ten miles with advantage, but they must not run twenty yards to catch a train. They may play golf all day if they like; but it is often advisable for them, instead of taking a long drive, in which every muscle of their body is put on the strain, to take two shorter drives, and make up for the loss in driving by fewer strokes at putting. Above all things they ought to avoid getting angry. Emotion, and especially angry emotions, raises the tension very greatly, and poor John Hunter's death was a sad example of the fatal consequences of anger.

Ten grains of potassium nitrate, with a like amount of bicarbonate and half a grain to two grains of sodium nitrite, as a powder, to be taken every morning in hot water or an aperient water, such as Apenta, tends to keep pressure down, and may be continued daily for a good many years. If this is insufficient, a quarter of a grain or half a grain of nitro-erythrol in the form of a tablet, in addition to this morning powder, may serve the purpose, and is more convenient for most people than a repetition of the morning dose at other times in the day. Nitro-glycerine tablets should be carried about, and if any pain in the chest comes on should be taken *immediately*, as they not only relieve pain but lessen the dangerous condition of which the pain is only a symptom. When the heart begins to fail in face of rising tension, it is frequently necessary to give strophanthus or digitalis with strychnine to steady it. In some cases, though these are exceptional, strophanthus or digitalis does better without strychnine, as the latter drug seems to cause palpitation and discomfort.

In all cases it must be borne constantly in mind that the nutrition of the cardiac muscle depends upon the quality of the blood going to it, and if the blood be laden with waste products its nutrition will be impaired. The closest watch must therefore be kept upon the intestinal canal, and the liver and bowels carefully attended to. A dose of blue pill or calomel twice a week, or even on alternate nights, followed by a saline in the morning, is one of the best methods of keeping the tension down. In many cases where the vessels are considerably thickened iodide of potassium in 5 or 10 grain doses three times a day, if the patient stands it, is very useful. Where the

iodide of potassium and sodium are not well borne a good result may be obtained from organic combinations such as iodipine and others. High frequency currents appear to have a great power of lowering blood pressure; I have many cases in which they have been of much service. I have heard of similar good effects of static electricity, but I have had no personal experience of its use.

In this paper I have said very little about the diastolic pressure, which is now generally reckoned to be that at which the oscillations of the artery are greatest. My reason for this is that I find it very much less easy to estimate the diastolic pressure accurately than the systolic with the ordinary instruments for clinical use. It is fairly easy to do this accurately with Gibson's sphygmomanometer, but this is not well adapted for bedside use. For clinical use I think Oliver's is the best for this purpose, and I have had one made by Boulitte, which may perhaps be ultimately useful. For ordinary purposes I think Martin's or Lockhart Mummery's and von Basch's sphygmomanometers and Dudgeon's sphygmograph are the most convenient instruments.*

* These instruments can be obtained from Mr. Hawksley, 357, Oxford Street.


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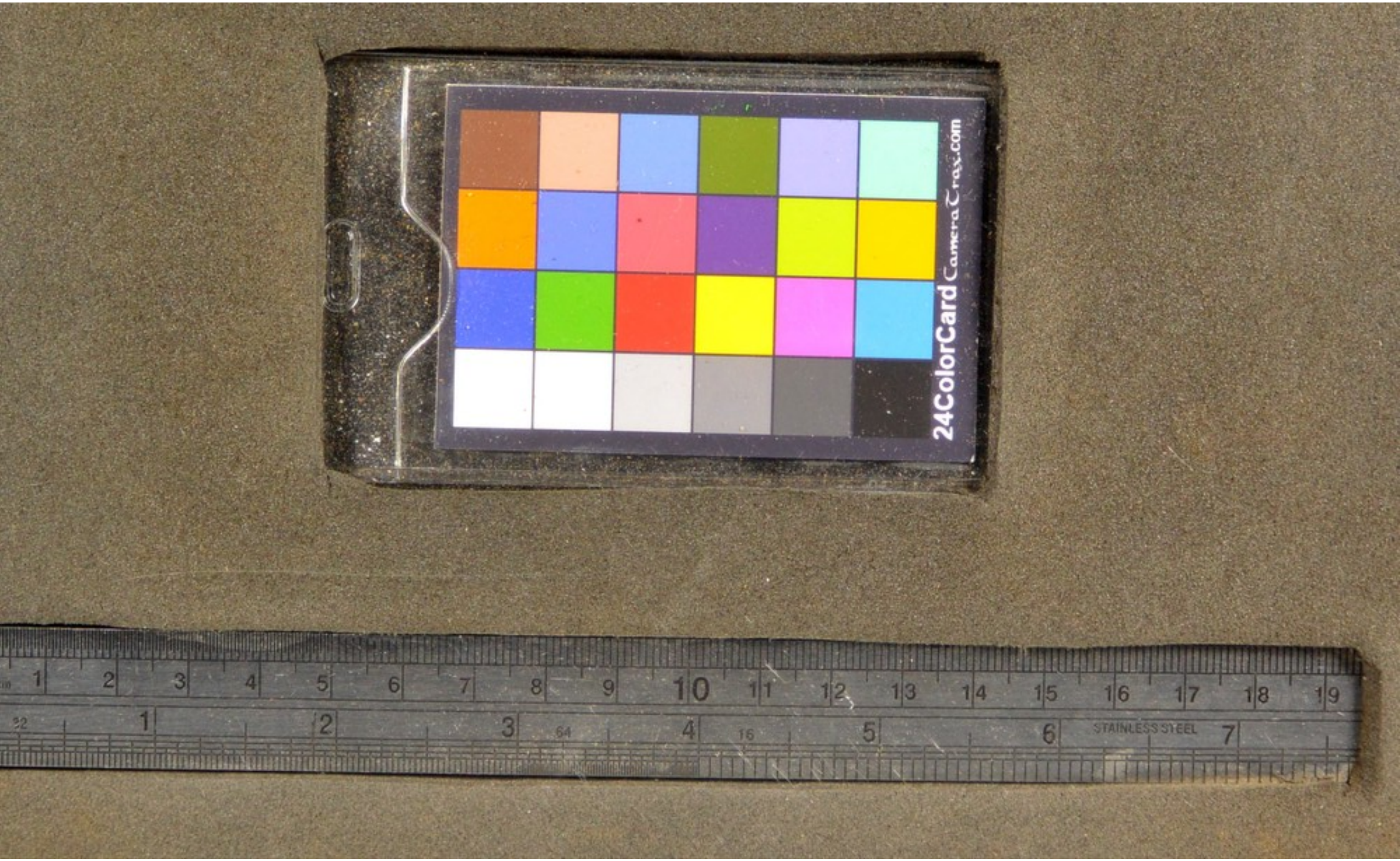
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