

ON THE PHYSIOLOGY OF VOMITING AND THE ACTION OF ANTI-EMETICS AND EMETICS.

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THE act of vomiting consists in the forcible expulsion of the contents of the stomach through the œsophagus and mouth. It may seem almost unnecessary to mention the œsophagus at all, for anything passing from the stomach to the mouth must needs do so through the œsophageal tube. And yet this fact is not always borne in mind, and the active share which the œsophagus takes in producing emesis being forgotten, a false conception of the mechanism of vomiting is formed. For a long time opinions were divided regarding the part taken by the stomach in the expulsion of its contents. Some stated that this was chiefly effected by the active contractions of the gastric walls. Others affirmed that the stomach was entirely passive, and was merely emptied by the mechanical pressure exerted upon it by the simultaneous contraction of the diaphragms and abdominal muscles. It has now been shown that the first view is incorrect, and that the movements of the stomach cannot expel its contents¹ except in rare instances.² Vomiting consists essentially in the simultaneous contraction of the abdominal muscles and diaphragm, which press on the stomach so as to squeeze out its contents. When these muscles are prevented from acting, either by cutting them across or by paralysing them with woorara, vomiting does not occur, although the stomach may be moving actively.

¹ Magendie, "Mémoire sur le vomissement," p. 23 ; Gianuzzi, "Centralblatt der med. Wissenschaften," 1865, p. 3.

² Budge, "Die Lehre vom Erbrechen," p. 34.

On the other hand, vomiting may be produced by the contraction of the diaphragm and abdominal muscles, although the stomach remains perfectly quiet, and even when it is replaced by a simple bag. This was shown by the well-known experiment of Magendie.¹

This physiologist removed the stomach of a dog and attached a pig's bladder filled with fluid to the œsophagus in its place. He then injected tartar emetic into the veins of the animal, and found that vomiting occurred in the same way as if the stomach had been *in situ*. He noticed, too, that vomiting could be produced by the contraction of the diaphragm alone, after the whole of the abdominal muscles had been cut away, the linea alba only being left,² and also, though imperfectly, by the contraction of the abdominal muscles alone, after the diaphragm had been rendered nearly motionless by section of the phrenic nerves.³ In ordinary vomiting, however, the diaphragm and the abdominal muscles co-operate together.

But it is quite evident that in vomiting there is something more than mere pressure of the stomach between the diaphragm and the abdominal muscles. In severe coughing the stomach is squeezed violently, but its contents are not usually expelled. The reason of this is, that in coughing the œsophagus remains firmly contracted, and prevents anything escaping from the stomach. In the act of vomiting, on the contrary, the œsophagus relaxes, and allows the gastric contents to pass freely through it.⁴ In vomiting, therefore, there are two factors, viz. (1), pressure on the stomach; (2), a relaxed condition of the œsophagus, especially at its under end, just where it joins the stomach. This under end is sometimes called the cardiac sphincter of the stomach, although there does not appear to be any distinct band of fibres thicker than the rest at this point, as the name would imply.⁵

If either factor is wanting, vomiting will not take place. The relaxation of the sphincter is of no use if the muscles do

¹ Magendie, *op. cit.*, p. 19.

² Magendie, *op. cit.*, p. 23, and Budge, "Die Lehre vom Erbrechen," p. 43.

³ *Op. cit.*, p. 21.

⁴ Schiff, Moleschott's *Untersuchungen*, Bd. x. p. 378.

⁵ Gianuzzi, "Centralblatt der med. Wiss.," 1865, p. 3.

not contract, and they will exert themselves in vain if the cardiac sphincter remains contracted. This is seen in retching, which sometimes occurs without vomiting, even when the stomach is tolerably full.

The relaxation of the cardiac sphincter is effected by contraction of the longitudinal fibres which run along the under end of the œsophagus below the diaphragm, and then radiate obliquely over the stomach. When these contract, they draw the cardiac end of the stomach nearer to the diaphragm, and at the same time dilate the cardiac orifice.¹ When they are paralysed, vomiting becomes impossible. If their innervation is disturbed, so that they do not work in concert with the diaphragm and abdominal muscles, vomiting will occur only rarely, or not at all; for in such a case, when the abdominal muscles contract, the cardia will probably be closed; and when the cardiac orifice is open, the abdominal muscles will probably not contract.² Thus, neither action is of any use, and it is only when, by some accident they happen together, that vomiting takes place.

It would be difficult for the muscles to exert any great pressure on the stomach if it were nearly or quite empty, but they will do so effectually if it be full. For this purpose it will not matter very much whether it is filled with food or air; and so it seems that both animals and men swallow air before vomiting. The emptier the stomach, the more air do they require in order to distend it, and the oftener do they swallow air. But it is impossible to swallow air alone; saliva must be swallowed at the same time. The ordinary secretion of saliva would probably be insufficient for this purpose, and we generally find that vomiting is preceded by such profuse salivation as will enable many swallowing movements to be made rapidly one after another.

When the stomach is very full, vomiting is somewhat difficult, for the organ then turns forward in such a way as to form a fold at the lower end of the œsophagus, and thus partially prevent the exit of its contents. Vomiting never occurs in the horse or rabbit, and rarely in guinea-pigs. This is probably due to the great length of that part of the œsophagus which lies

¹ Schiff, Moleschott's Untersuchungen, Bd. x., p. 380.

² Schiff, *op. cit.*, p. 399.

between the diaphragm and stomach, so that the contraction of the longitudinal fibres causes it to fold and obstruct the cardiac orifice instead of opening it as in other animals.

The phenomena of vomiting may be thus described. Uneasiness is felt; the inspirations become deeper; several swallowing movements are made which sometimes carry down sufficient air to distend the stomach moderately. After several deep inspirations there suddenly comes one which is deeper still. Then, instead of this being followed by expiration, the glottis shuts to prevent the escape of air, the diaphragm contracts still more, thus descending more deeply into the abdomen, and pulling the ribs together; the abdominal muscles forcibly contract; the left half of the stomach is drawn upwards,¹ and the cul-de-sac flattened out; the cardiac orifice dilates, and the contents of the stomach are forcibly expelled. The pylorus remains firmly contracted, and allows but little to escape into the intestines. The closure of the pylorus has been ascribed by Budge,² partly to mechanical compression by the liver, which is pushed down upon it by the diaphragm, and partly to contraction of its muscular fibres induced by the irritation of the pressure. It seems more probable, however, that the contraction of the pylorus is not due to any local cause, but is regulated, like that of the other muscles, by the nervous centre which presides over the act of vomiting.

This centre is situated in the medulla oblongata, and it is identical with or closely connected with the nervous centre which regulates respiration. It is connected with the abdominal muscles, the diaphragm, the stomach, and the oesophagus, by the intercostal, phrenic, and pneumogastric nerves respectively. Along these it sends the motor impulses which make the muscles contract and produce vomiting. For the sake of simplicity these nerves have not been represented in the diagram.

The nervous centre for vomiting is supposed to be closely connected or identical with the respiratory centre in the medulla oblongata. The reasons for this supposition are (1) that the movements of vomiting are excessively great and somewhat modi-

¹ Schiff, *op. cit.*, p. 362.

² Budge, "Die Lehre vom Erbrechen," p. 49.

fied respiratory movements, and (2) that emetics excite the respiratory centre, while depression of the respiratory activity stops vomiting. Usually it is easy, by vigorous artificial respiration, to saturate an animal's blood with oxygen, and then, having no longer any need of fresh air, it ceases to breathe for a while; and any person after taking a few deep breaths will find that he can hold his breath a much longer time than before. The condition in which no respiration is needed, and consequently no movements of breathing are made by the animal, is termed *apnoea* by the Germans, while we use the same term to signify an aggravated condition of dyspnoea. I use the term in its German sense. If emetics are injected into the veins, the respirations become more frequent; and it is stated by Hermann and Grimm that no *apnoea* can be produced by the most vigorous artificial respiration. And on the other hand, the artificial respiration prevents the occurrence of vomiting so long as it is continued.¹ This seems to indicate that the respiratory centres are closely connected, and it is by no means improbable that some of the nerve cells and fibres which compose the respiratory centre in the medulla oblongata also form part of the centre for vomiting. Yet the movements of respiration and vomiting, although somewhat alike, differ very considerably from each other; and we are, I think, justified in supposing that the centres for respiration and vomiting are not absolutely identical,² although a part of each may possibly be common to both. Moreover, the centre for vomiting may be completely paralysed by narcotics, such as opium, chloral, or chloroform, while the respiratory movements continue or may even be increased.³ I have also found that in chloral narcosis it is easy to produce *apnoea* after tartar emetic has been injected into the blood and sulphate of zinc into the stomach. This could hardly be the case if the centres for respiration and vomiting were identical. I shall therefore speak of them as distinct.

The nervous centre for vomiting is usually excited to action reflexly by irritation of certain afferent nerves. They may be divided into two classes: (*a*) those which pass upwards from

¹ Grimm, Pflüger's Archiv, iv. p. 205.

² Harnack, Arch. f. exp. Path. u. Pharmakol, ii., p. 285.

³ Ibid, p. 90.

the body to the medulla, and (b) those which pass downwards to it from the brain. It is easy enough to allot a few nerves to one or the other of these classes, but there are many others which we cannot with certainty place in either division. Thus, the pharyngeal branches of the glosso-pharyngeal nerve pass upwards to the medulla and act upon it independently of the brain, for tickling the fauces will produce vomiting in a man whose cerebral faculties are so besotted with alcohol that he hardly feels blows or bruises which would cause him severe pain when sober. On the other hand, the nerves of taste and smell only act on the vomiting centre through the brain, for persons in the mesmeric sleep will drink the most nauseous mixtures with a smiling face, while the very remembrance of disgusting tastes, sights, and odours would make them sick in their ordinary waking condition. But we cannot so readily say how the vomiting centre is excited by those nerves which convey painful impressions from various parts of the body. Severe pain will often cause nausea and vomiting, although the pain may originate in the most various parts of the body. Thus, a person suffering from a loose cartilage in the knee-joint tells me that the pain it occasions always brings on nausea and vomiting. A painful wound may produce a similar effect, and Helmont¹ relates that after dislocating a joint, nausea and vomiting came on, and lasted until the bones were replaced. A blow on the testicles, an inflamed ovary, and the passage of a calculus along the gall-duct and ureter, all cause pain and often vomiting. Some say that the vomiting is due to the pain, and that it only lasts while the pain continues, the pressure of the calculus and the irritation it thereby causes having nothing to do with it. It may be the case, then, that the irritation of the nerves of a limb in the case of a loose cartilage or a dislocation, of the hepatic and renal nerves in the case of a calculus, and of the intestinal, ovarian, and other nerves, all act through the sensory portions of the brain; but it is not yet certain that they do so, and it is so much more convenient to represent them as going direct to the medulla, than as going round to it *via* the cerebrum, that I have given them a direct course in the accompanying diagram. In it I

¹ Quoted by Budge, *op. cit.*, p. 15.

have represented the following as the afferent nerves which pass up directly from the body to the medulla oblongata, and excite to action the vomiting centre situated there:—Pharyngeal branches of the glosso-pharyngeal; pulmonary branches of the vagus; gastric branches of the vagus; gastric branches of the

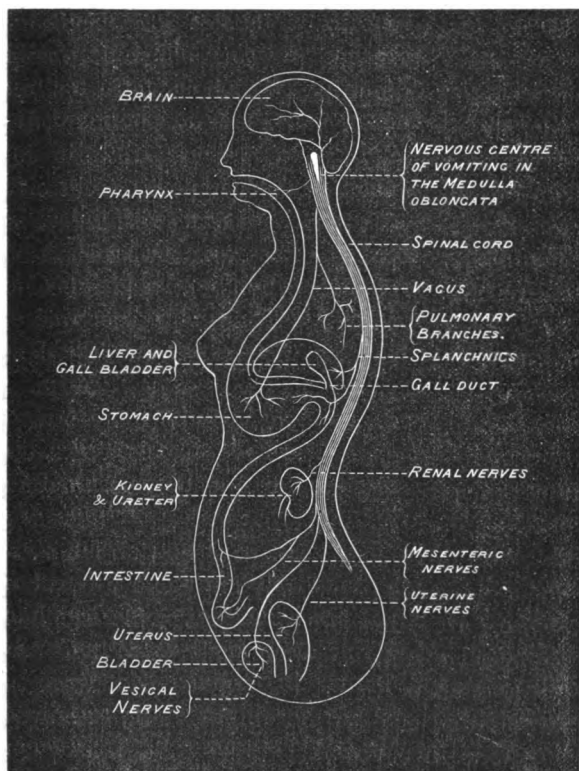


FIG. 1.—Diagram showing the afferent nerves by which the vomiting centre may be excited to action.

splanchnic; hepatic branches of the splanchnics (of the vagus?) renal nerves; mesenteric nerves; uterine nerves; ovarian nerves; vesical nerves.

Those fibres which are represented as passing down from the brain may indicate the path by which the vomiting centre is

excited, by impressions of sight, taste, smell; by simple recollections or imaginations; by blows on the head, or inflammation of the brain or its membranes.

After this general description, we will proceed to examine these nerves more particularly.

They are—1. The branches of the glosso-pharyngeal nerve, distributed to the soft palate, root of the tongue, and pharynx.¹ Tickling these parts with the finger or with a feather is one of the readiest methods of inducing vomiting; and sometimes, as in cases of poisoning by mushrooms, the stomach can be emptied more readily by it than even by tartar emetic. When they are inflamed, they not unfrequently give rise to a cough, which is distinguished by violent expulsive efforts, nearly resembling retching, and not unfrequently accompanied by true retching, or even vomiting. This is often seen in children. One may frequently hear parents chide their children for coughing so noisily, and say to them, "Don't cough so loud," "Restrain your cough." Whenever these expressions are used, one may be almost certain that the chief cause of the cough is inflammation of the fauces, although this may sometimes be accompanied by bronchitis. 2. The gastric branches of the vagus and splanchnic nerves. It has been found by Blondlot and Bernard that when the mucous membrane of the stomach is gently tickled it becomes very rosy, and secretes gastric juice freely. If the mechanical irritation is carried further, so as to produce pain, the rosiness disappears and the surface becomes pale; the secretion of gastric juice is arrested; ropy mucus is poured out instead; and the movements of the stomach are much increased. At the same time the animal shows signs of uneasiness and nausea, and if the irritation is continued vomiting occurs, and bile has been observed to flow into the stomach.² Similar phenomena are produced by various kinds of food and medicine. Thus, the introduction of food into the stomach usually causes secretion of gastric juice; but when it is hard and indigestible, or irritating, it may arrest digestion and cause vomiting. Dilute bitter infusions give appetite, and seem to aid digestion; but a strong infusion of quassia will act as an emetic. As the vagi

¹ Budge, "Die Lehre vom Erbrechen," p. 131.

² Quoted in Carpenter's "Physiology," 7th edition, p. 128.

are the sensory nerves of the stomach,¹ and several of these phenomena can be produced by irritating their trunks,² it is probable that they have a good deal to do with the conduction of impressions from the stomach to the vomiting centre. But they are not the only afferent nerves from the stomach; for irritation of this organ will produce vomiting after they have been cut.³ In this case it is probably through the splanchnic nerves that the irritation is conveyed to the medulla. 3. The branches of the vagi and splanchnics going to the liver and gall-duct. Vomiting is of frequent occurrence in hepatitis, and during the passage of a calculus through the gall-duct.⁴ It is probably due to irritation of these nerves; although, as we have already said, it is difficult to decide whether the nerves act directly on the medulla or only indirectly through the brain. 4. The pulmonary branches of the vagus. Irritation of these branches is not a very common cause of vomiting, and it may be doubted whether they cause vomiting directly or only indirectly. It is possible that the vomiting in the early stages of phthisis⁵ may be due to these nerves, and it may be well to bear them in mind, and to examine the lungs in cases of vomiting without any obvious cause. 5. The renal nerves. Vomiting occurs in nephritis and when calculi are irritating the pelvis of the kidney or passing down the ureter. 6. The mesenteric nerves. Vomiting is almost always present in cases of strangulated hernia or intussusception. It also occurs in animals after a ligature has been tied firmly round a piece of the small intestine. It may be arrested by dividing the mesenteric nerves passing from the ligatured point.⁶ Its occurrence in general peritonitis is probably due likewise to irritation of the mesenteric nerves. 7. The vesical nerves. It is somewhat doubtful whether the vomiting sometimes observed in cystitis is due to irritation of these nerves or to irritation of other nerves by the extension of the inflammation from the bladder to the

¹ Budge, "Die Lehre vom Erbrechen," p. 127.

² Rutherford, *Trans. Roy. Soc. Edin.*, 18.

³ Budge, *op. cit.*, p. 94.

⁴ Watson, "Practice of Physic," 4th edition, pp. 586, 606.

⁵ Craigie, "Practice of Physic," vol. ii., p. 996; Watson, *op. cit.*, vol. ii. p. 617.

⁶ Schiff, *Moleschott's Untersuchungen*, Bd. x. p. 390.

adjoining parts.¹ 8. Uterine nerves. Irritation of these nerves is one of the commonest causes of reflex vomiting. It may be produced either by the presence of the foetus in the uterine cavity, by inflammation of the womb itself, or by electrical irritation of the uterine plexus.² 9. Ovarian nerves. Vomiting is a symptom of inflammation of the ovaries.³ 10. Irritation of various parts of the brain. Vomiting may be produced by mental states excited by a disagreeable taste, by the sight or smell of disgusting objects, or even by the mere recollection of these; by emotions, such as anger, suspense, grief, joy, &c.; continued and intense thought, &c.;⁴ by concussion; by the irritation consequent on loss of blood, or caused by the withdrawal of blood from the general circulation and its accumulation in the abdomen in cases of shock.⁵ Vomiting is one of the most marked symptoms in meningitis and cerebritis, and is noticed also in some cases of tumours of the brain. Budge states that the cerebral centre for the movements of the stomach is the right corpus striatum and optic thalamus, especially the latter.⁶ Irritation of these parts causes the stomach to move, while irritation of the corresponding parts on the left side of the brain have no action on the stomach whatever. From this observation we are led to suspect that when any irritation exists in the right hemisphere it will occasion vomiting more readily than irritation in the left hemisphere; and, according to Budge, this is actually the case.

There are thus many conditions of the brain which induce vomiting, and if we knew a little more about them we might separate them as we have done the nerves of the stomach, uterus, &c., instead of representing them all together, as we have done in the diagram. But even if we count them as one, we have altogether no less than ten nerves indicated in the diagram as exciting the vomiting centre reflexly. I shall not attempt to enter here on the means of diagnosing between the vomiting arising from irritation of all these nerves, but shall enter at once on the treatment.

¹ Craigie, "Practice of Physic," vol. i. p. 930.

² Pflüger's Archiv, Bd. viii. p. 351.

³ Hooper's "Physician's Vade Mecum: Oöphoritis."

⁴ Budge, op. cit., p. 153.

⁵ *Practitioner*, vol. xi. p. 250.

⁶ Budge, op. cit., p. 116.

As vomiting is generally a reflex act consequent on the irritation of some nerve, its rational treatment is either to remove the irritant; or, if this is impossible, to lessen the irritability of the nervous centre in the medulla, so that it no longer responds to the irritation. Not unfrequently we combine both methods. In inflammation of the fauces we use soothing or astringent gargles, confections, or glycerines. When the stomach is irritated by indigestible food or acrid matters present in its cavity, a large draught of warm water and mustard will often cause their ejection, and thus forms one of the best means for arresting further vomiting. If the irritant consists in an inflamed condition of the mucous membrane of the stomach itself, such treatment would be of little service, and we must endeavour to lessen the inflammation and to render the sensory nerves of the stomach less irritable. This we do by the use of bismuth and of hydrocyanic acid. It is well known that if one holds the finger over the mouth of a bottle of hydrocyanic acid for a few minutes it becomes numb and loses its sensibility; and we have every reason to suppose that the acid acts in the same way on the nerves in the wall of the stomach, so that the inflammatory condition present there no longer irritates them to the same extent. At the same time, however, we may give some drug to lessen the irritability of the vomiting centre in the medulla, such as morphia or chloral. Bromide of potassium has a considerable power to lessen most reflex actions, that of vomiting among the rest, and my friend Dr. Ferrier has used it with great success in sea-sickness. Acting on his suggestion, I have found the following formula very useful in gastric catarrh and subacute gastritis:—

R. Bismuthi subnit, gr. x.
 Potass. bromid., gr. xv.—xx.
 Acid hydrocyan. dil., ℥v.
 Spt. chloroform, ℥x.
 Mucilag. tragacanth, fl. ʒij.
 Aqua, ad. fl. ʒj.

Sg. To be taken every three or four hours.

The medicine should be given about ten minutes before food, so as to diminish the irritability of the stomach and prevent the

rejection of the nourishment, and it is often advisable to make the patient lie down on the left side either during or immediately after the meal. A tendency to vomit is often increased by lying on the right side. This is attributed by Budge¹ to the greater pressure exerted by the liver upon the stomach in this position, and this may be correct. It seems to me probable, however, that the mere weight of the stomach itself and of its contents will exert a drag upon it, directed more or less towards its pyloric end, either in the sitting posture or when recumbent on the right side. Now, the stomach is much more sensitive to any pull exerted in this direction than to one towards the cardia, even in the normal condition, and it is likely to be still more so when rendered hyperæsthetic by inflammation. I am therefore inclined to ascribe the benefit derived from lying on the left side to the absence in this position of any drag on the stomach and the irritation it would cause, rather than to any change in the relations of the liver.

I have already mentioned that it is doubtful whether irritation of the pulmonary branches of the vagus induces vomiting directly in the same way as irritation of the gastric branches does; but vomiting, occasionally of a very obstinate kind, is certainly found in phthisis, and it may be due to this cause. When it seems to be caused by the cough, it is sometimes checked by doses of six to ten grains of alum. This is rather hard to explain on the supposition that the vomiting is here due to the irritation of the pulmonary nerves, for the alum can have but little sedative action either on the lungs themselves or on the medulla. If we look at a patient coughing and mark the swollen veins on the forehead and neck, and remember that these are merely the visible signs of the general congestion throughout the whole venous system, including the veins of the stomach, we can hardly help thinking that the constant distension of the gastric veins during the almost incessant paroxysms must either in itself act as an irritant and thus induce vomiting, or lead to such a condition of the mucous membrane as will do so. If this be so, the action of alum as a local astringent in removing congestion may well explain its beneficial effect in arresting vomiting.

The same principles prevail in the treatment of vomiting due

¹ Budge, *op. cit.*, p. 66.

to irritation of the other abdominal nerves as of those of the stomach ; but in them we can less easily soothe the local irritation by local means, and we are obliged to depend still more on remedies which will act on the medulla. But we by no means neglect to remove the irritant as far as possible. In hepatitis we strive to subdue the inflammation by blisters and depletion ; in intussusception we try to restore the bowel to its normal condition by copious injections of water or oil ; in strangulated hernia we relieve the incarcerated bowel by an operation ; and in inflammation of the uterus, ovaries, and bladder, we have recourse to depletion, blisters, and other appropriate local remedies. Even in pregnancy, if other means fail, we are sometimes obliged finally to remove the irritant by inducing premature labour, and sacrifice the offspring in order to save the life of the mother.

But in such cases we base our hopes of arresting vomiting rather on our ability to diminish the excitability of the vomiting centre by means of opium, bromide of potassium, chloral, or hydrocyanic acid, than our power to remove the irritant.

In sea-sickness it is difficult to say what the irritant is which excites the vomiting centre to action. For my own part, I am inclined to believe that it is the shaking and dragging of the abdominal viscera caused by the motion of the ship. Subjective sensations point unmistakably to this as the cause, and the testimony they afford is strengthened by the fact that the sickness becomes less troublesome if the movements of the abdominal viscera are restrained by a tight bandage applied externally, or even by distension of the stomach with food. Whatever be the cause, however, the treatment is chiefly directed to the vomiting centre, and my friend Dr. Ferrier has found bromide of potassium in large doses of especial service in preventing as well as arresting the distressing nausea and vomiting which make many persons regard a trip across the Channel with perfect horror.

Thus far we have directed our attention to the act of vomiting, chiefly with the view of arresting it. Sometimes, however, we wish to induce it, and for this purpose we employ various substances which are generally all classed together as emetics. They naturally divide themselves into two subdivisions. Those

belonging to the one act, like mustard, only when introduced into the stomach; those belonging to the other act like tartar emetic, both when introduced into the stomach and when injected into the veins. The first class includes, besides mustard, the sulphates of zinc and copper, as well as other irritant substances not usually employed as emetics: they induce vomiting reflexly by irritating the nerves in the stomach; and as the effect they produce is the same as that of scratching the mucous membrane, they are sometimes called mechanical emetics. The second class includes tartar emetic, ipecacuanha and its active principle emetia, apomorphia, veratria, delphinia, cyclamin, asclepiadin, and sanguinarin: they also cause vomiting when injected into the veins, but they are not used medicinally as emetics.

It used to be considered certain that emetics of this class produce vomiting by acting directly on the nervous centre in the medulla oblongata, to which they were conveyed by the blood, and not by exciting it reflexly by irritating the stomach, like the mechanical emetics. This view seems to be to a certain extent correct, and the vomiting which follows the injection of such a substance as tartar emetic into the veins is probably partly due to its direct action on the vomiting centre, but partly also to its reflex action on this centre through irritation of the stomach. For, as Buchheim has pointed out,¹ when emetics are injected into the blood, they are carried by it to the stomach as well as to the nerve centres, and thus they may irritate it and induce vomiting in exactly the same way as if they had been passed into it through the cesophagus. Tartar emetic, for example, will cause vomiting, either when injected into the veins or when swallowed, but in both cases it reaches the mucous membrane of the stomach and irritates it. It is true that when injected into a vein it reaches the vomiting centre also, but when swallowed it is sometimes rejected almost entirely, so that little or none reaches the vomiting centre. In both cases, then, the emetic acts on the stomach, but only in one does it act on the medulla. Yet vomiting occurs in the one case as well as in the other, and it is therefore only natural to attribute it to the action on the stomach, and not to its

¹ Buchheim, "Arzneimittellehre," 1853-56, p. 304.

action on the medulla. Besides, tartar emetic only precipitates albumen when in presence of an acid; the gastric juice in the stomach therefore causes it to precipitate the albumen in the mucous membrane. This produces irritation and inflammation in it, when no change whatever can be detected, either by the naked eye or the microscope, in other organs, such as the medulla.¹ It may thus be fairly said that until we do find a change in the medulla, we ought to ascribe the vomiting only to the action of the emetic on the stomach.

But having said thus much on the one side of the question, let us turn to the other and see what arguments may be adduced in proof of the action on the medulla being the true cause of vomiting. First of all comes the somewhat staggering fact, that after Magendie had removed the stomach of a dog altogether and replaced it by a bladder, the animal vomited when tartar emetic was injected into the veins. If the drug only caused vomiting by irritating the stomach, how can it do so after the stomach is removed? Hermann,² who supports the gastric action of tartar emetic, tries to get over this difficulty by supposing that it irritates the mucous membrane of the œsophagus and pharynx, and that the vomiting in Magendie's experiments was induced by its action on these parts. This explanation may be correct, but these parts, instead of being acid, like the stomach, are alkaline, like the medulla, and there is therefore no reason why the tartar emetic should act on them rather than the nervous centre. This experiment of Magendie's in itself affords great support to the old doctrine of the central action of tartar emetic, and recent experiments on the action of apomorphia render it strongly probable that apomorphia, another emetic of the same group, likewise acts on the medulla directly. Apomorphia, although of recent introduction, having been discovered by Mathiesson in April 1869, and first investigated by Gee a month afterwards, bids fair to supplant other emetics, as it is so rapid and certain in action, and can be applied either subcutaneously or administered by the mouth with equal ease. Gee noticed that small doses of $\frac{1}{2}$ of a grain caused vomiting in dogs, and large ones occasioned in ad-

¹ Ipecacuanha does so also. Gubler, *Comment. Thérap.* 1868, p. 627; and D'Ornellas, *Bull. de Thérap.*, tome lxxxiv, p. 199.

² Hermann, *Pflüger's Arch.* v. p. 280.

dition a curious *manège* movement, the animals running round in a circle¹ in somewhat the same way that Longet noticed them to do after a wound of the optic thalamus.²

This effect of apomorphia points to an action of the drug in the nervous centres, and is all the more interesting when we remember that Budge placed the cerebral centre for the stomach in the right thalamus.

Gee's experiments were repeated and extended by Siebert,³ who noticed that apomorphia produced great acceleration of the respiration, pointing distinctly to excitement of the respiratory centre, which is closely connected with the centre for vomiting. Now, the respiratory centre, like the vomiting centre, may be excited reflexly by irritation of the vagi; but Harnack,⁴ in a recent research, has found that the excitation caused by apomorphia is not reflex, but is due to the direct action of the drug on the respiratory centre itself. As this centre and that for vomiting are so closely connected, it seems a fair inference that the apomorphia acts directly on the vomiting centre also, and produces emesis by irritating it. As both tartar emetic and ipecacuanha excite the respiratory centre also, it is probable that like apomorphia they act directly on the medulla, and thus we are led back to the old notion of the central action of this group of emetics. But as these are such weighty arguments in favour of their reflex action, we can hardly help coming to the conclusion that they may act either centrally or reflexly, and in all probability usually combine the two actions whenever they are introduced into the blood. When apomorphia is injected subcutaneously or into a vein, a smaller dose is sufficient to produce vomiting than when it is introduced into the stomach,⁵ while a larger dose of tartar emetic must be injected than would be sufficient if administered by the mouth. This seems to show that the emetic effect of apomorphia is due chiefly to its action on the medulla, and less to its action on the stomach, while tartar emetic acts less on the medulla and

¹ Gee, "Clinical Society's Transactions," vol. ii. p. 168.

² Longet, "Traité de Physiologie."

³ Siebert, Untersuch. über d. physiol. Wirkungen des Apomorphins. Inaug. Diss. Dorpat, 1871, p. 60.

⁴ Harnack, Arch. f. exp. Pathol. u. Pharmakol. Bd. ii. p. 283.

⁵ Greve, Berlin. Klin. Wochensch. 1874, p. 351.

more on the stomach. It has been already mentioned that tartar emetic only acts as a powerful irritant when it comes in contact with an acid, especially hydrochloric acid, as it does in the healthy stomach. Consequently, its irritant action on the stomach will be much less if the hydrochloric acid usually present in the organ should be diminished or absent. Now, it has been found by Manassein¹ that the proportion of acid in gastric juice is diminished, or the acid altered, during the febrile condition; and clinical experience long ago showed that tartarated antimony did not exert its usual emetic action in persons suffering from pneumonia, or, as physicians were accustomed to express it, there was a tolerance of the drug.

The employment of emetics is not nearly so extensive now as it formerly was. They may be administered (1), for the simple purpose of evacuating the contents of the stomach and duodenum; (2), for the effect of the muscular movements during vomiting upon other organs; (3), for their effect on the nervous system.

In cases of poisoning, the first thing to be done is to remove the poison from the stomach, and thus prevent it either from injuring the gastric walls themselves or from being absorbed into the blood. We usually employ sulphate of zinc or copper as an emetic for this purpose.

In indigestion, the case of the patient is often really one of slight poisoning, although we are rarely accustomed to regard it as such. Not only do the undigested articles of food act as mechanical irritants to the stomach, but they undergo fermentation, and the products of this are real poisons. Butyric acid, for example, is frequently produced by the fermentation of food in the stomach, and, as Otto Weber has shown, it is a powerful poison. The same is the case with the sulphuretted hydrogen, which gives the disagreeable odour of rotten eggs to the eructations of some patients. The irritating matters in the stomach not unfrequently cause nausea and headache, without leading to vomiting; but if they should be ejected, nausea generally ceases. Therefore, the best treatment frequently is to give copious draughts of warm water, or warm water and mustard. We use warm or tepid water because cold lessens the irritability of the stomach, and thus prevents emesis altogether; and we add

¹ Manassein, Virchow's Archiv, 1872, lv. p. 413.

the mustard in order to stimulate the gastric walls. But it is not those matters only which have been introduced into the stomach which are evacuated by vomiting. A quantity of the gastric secretions is also ejected, and anything they may happen to contain is thus removed from the body.

In a former paper ¹ I explained that certain substances, when swallowed, were absorbed by one part of the intestinal canal, excreted by another, and again re-absorbed, so that they may

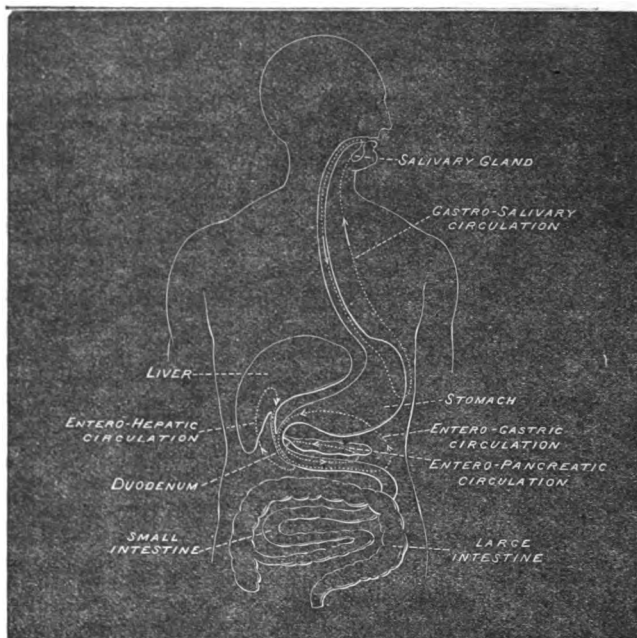


FIG 2.—Diagram showing the circulation of substances in the organism, caused by their absorption, excretion, and re-absorption.

sojourn a long time in the body before being finally eliminated. Thus iodide of potassium is absorbed by the stomach, excreted by the salivary glands, and re-absorbed by the stomach, so that it goes round and round in the gastro-salivary circulation. Most metals, lead probably among the rest, are excreted in the bile and absorbed by the small intestine, so that they go round in the entero-hepatic circulation. Purgatives, by hurrying the

¹ *Practitioner*, vol. xii. p. 408.

secretions through the intestinal tube, prevent re-absorption to some extent, and thus aid in the expulsion of the metals or other substances they contain. But it is much further from the duodenum to the anus than from the duodenum to the mouth; and anything taking the longer route is much more likely to be absorbed than if it took the shorter way. In violent vomiting, bile is evacuated by the mouth without getting a chance of re-absorption; and a course of emetics, therefore, seems far better suited to remove bile and anything contained in it—such as lead or copper—than a course of purgatives can be. It is not improbable that it is so; and a mixed course of emetics and purgatives is really exceedingly useful in lead-poisoning;¹ but the discomfort which attends vomiting causes a very decided preference to be given to purgatives. Nor are metals the only substances which circulate in this way; bile itself does so, and its removal by vomiting gives relief in biliousness. Lussana² also thinks that malarial poison, whatever that may be, circulates with the bile in the portal system; and it is exceedingly interesting to learn that the natives of Morocco, as my friend Dr. Duckworth informs me, having no quinine, actually treat intermittent fevers by emetics. It is stated also by eminent physicians that an emetic at the beginning of a continued fever, such as typhus, is of great service; and it is possible that it acts there in the same way as we suppose it to do in intermittent fevers, viz., by removing the fever poison.

The violent expulsive efforts in vomiting do not act only on the stomach; they affect also the lungs and expel anything in the air-passages still more effectually than can be done by coughing. Emetics are therefore used in croup and bronchitis. The gall-bladder is also much compressed by the descending diaphragm, and the bile is forced through the common bile-duct, instead of trickling through it with almost no pressure at all, as it usually does. Any obstruction in the duct which the ordinary pressure of the bile would never move, will then be pressed on into the duodenum, unless it be too firmly impacted. Gallstones in the duct, and jaundice depending on the obstruction they occasion, can thus be removed by the action of emetics; but

¹ Dictionnaire des Sciences Médicales, 1815, tome ii. p. 522.

² Lussana, *Lo Sperimentale*, tome xxix. 1872, p. 358.

there is always the danger that, if the obstruction is at all firm, the violent efforts may burst the gall-bladder and lead to the death of the patient.

Finally, emetics may be used to produce an "impression on the nervous system,"—a vague term which may mean anything or nothing, and may be explained by everyone as best he pleases. The facts are, that in cases of epilepsy, where the fits tend to recur every few minutes and the unconsciousness may last for hours, an emetic may sometimes put an end to the attack. An impending ague fit may sometimes be arrested by an emetic given just before it is expected to begin.¹ It may be also useful in hysterical fits; but these are so readily arrested by a galvanic shock, that few would think of using anything else while a battery is at hand.

It seems probable that the nervous excitement which causes the epileptic or other fit, discharges itself in the exertion of vomiting, but it would take too long to enter on this subject here.²

To sum up, the chief points in relation to vomiting and the action of drugs upon it are:—

1. Vomiting consists in two factors, viz. (1) the simultaneous compression of the stomach by the abdominal muscles and diaphragm, and (2) the opening of the cardiac orifice by the contraction of the longitudinal fibres of the cesophagus.

2. When innervation is disturbed, these two factors do not occur together, and thus retching may occur without vomiting.

3. The movements of vomiting are correlated by a nervous centre in the medulla oblongata, from which impulses are sent down through various motor nerves to the muscular structures engaged in the act.

4. This nervous centre is probably closely connected with the respiratory centre, but is not identical with it.

5. It is usually set in action reflexly by irritation of the pharyngeal, gastric, hepatic, enteric, renal, uterine, ovarian, and possibly also by the pulmonary and vesical nerves which come from the periphery towards it. It may also be excited by impressions sent down to it from the brain.

6. Vomiting may be arrested in two ways, either by removing

¹ *Materia Medica*, &c., by H. C. Wood, p. 362.

² See Lauder Brunton on "Inhibition," *West Riding Asylum Reports*, 1874.

the irritant which is exciting the vomiting centre, or by lessening the excitability itself, so that the centre no longer responds to the impressions made on it from without.

7. Emetics may be divided into two classes : those which act only on the stomach, and those which act on the vomiting centre also.

8. Tartar emetic probably acts in both ways. Tolerance of it is probably due to want of hydrochloric acid in the stomach.

9. Emetics may be used to evacuate the stomach and duodenum. They thus remove irritating matters, poisons generated in the stomach by putrefaction, bile, and metals or fever poisons circulating in the entero-hepatic circulation.

10. They may be also used to empty the bronchi and gall-bladder, or to cut short epileptic and to prevent ague fits.