

## REFLEX ACTION DURING GENERAL SURGICAL ANÆSTHESIA.\*

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MOST text-books and the current literature on anæsthesia contain meagre articles on the subject of reflexes that relate to surgical narcosis. Perhaps the writers consider that the subject properly comes under general physiology, but as a matter of fact there are so many important reflexes which are intimately associated with surgical anæsthesia that the subject should be given special study, investigation, and prominence by anæsthetists. By a thorough knowledge of the physiological phenomena presented by the behavior of reflexes, we are enabled to determine the depth of anæsthesia and consequently to regulate the dosage of anæsthetic agents. Reflexes are to a great extent guides as to the condition of the patient.

A reflex act (*re*, back; *flectere*, to bend), is an act following immediately upon a stimulus without the intervention of the will (Gould). For the production of a reflex act, three essential anatomical and physiological factors are necessary: first, an afferent nerve to receive and transmit the stimulus; second, a nerve cell centre or centres in the gray matter to receive, register, transfer, initiate, and transmit; third, a centrifugal efferent motor impulse to a muscle. This in brief is the mechanism necessary for a reflex action and constitutes what is known as a reflex arc. A suitable example of a reflex act is closure of the eyelid immediately when the conjunctiva is irritated.

In the general physiology of reflex action the reactions are divided into simple reflexes, co-ordinated reflexes, and convulsive reflexes; or partial reflex, widespread co-ordinated reflex, and widespread inco-ordinated reflex. Considered from an

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\* Read before the American Association of Anæsthetists, June 18, 1913.

anæsthetist's point of view, in order to determine the degree of action of narcotic drugs on the body, a specific classification is necessary; which I have arranged as follows:

Reflexes of the Eyelid: Cutaneous; ciliary; conjunctival; double conjunctival.

Reflexes of the Eye: Tarsocorneal; ciliocorneal; corneal; pupillary, including: *a*, reaction to light, *b*, marginal motility, *c*, crossed concomitant, *d*, ciliospinal or platysma.

Reflexes of Air Passages: Nasal; pharyngeal; laryngeal; palatal; rhythmical variations of respirations.

Rectal and vaginal.

Reflex cardiac and respiratory inhibition.

Reflex cardiac and respiratory acceleration.

Miscellaneous, as cutaneous in general, abdominal, peritoneal, labiomental, vomiting; direct motor.

Following is a brief description of the above:

#### REFLEXES OF THE EYELID.

*Cutaneous*.—During analgesia, or very light anæsthesia, if the integument covering the upper eyelid is rubbed by the point of the finger, an afferent impulse is transmitted along the infratrochlear to the nasal nerve, which is a branch of the ophthalmic division of the trifacial (fifth) nerve. This impulse is transferred in the gray matter and an efferent motor impulse is sent back by the facial nerve to its terminal branches, which are the temporal and malar, and cause a contraction of the orbicularis palpebrarum.

*Ciliary*.—This reflex is practically the same as the eyelid cutaneous, except that the sensory irritation is produced by brushing the eyelashes, and the irritation is also taken up from the lower lid by the palpebral branches of the infra-orbital of the superior maxillary of the fifth nerve. It is of value in light nitrous-oxide-oxygen anæsthesia.

*Conjunctival*.—Irritation of the conjunctiva causes an impulse to be taken up by the infratrochlear and palpebral branches of the trifacial nerve, which is reflected to the facial

nerve and causes contraction of the orbicularis, or a portion of it.

*Double Conjunctival*.—This reflex is the same as the conjunctival, except that both lid margins are stimulated at the same time. The afferent nerve terminals are separate and a greater "signal surface" is irritated. This reflex is of practical value during gas-oxygen analgesia or anæsthesia.

#### REFLEXES OF THE EYE.

*Tarsocorneal* (Parsons' reflex).—I wish to elaborate on this particular reflex because for eight years I have been investigating the anatomical, histological and physiological phenomena concerned in its production, and also its clinical application. So far as I am aware, this specific reflex has never been described except by myself, in 1907 (*Denver Medical Times*, August, 1907, p. 40). This reflex is produced as follows: The superior palpebral portion of the orbicularis is gently retracted upward by the anæsthetist's index, or preferably the middle finger, and by steady pressure the ciliary margin of the tarsal plate is pressed against the cornea directly over the pupil. The reaction which follows is a lateral movement of the lower lid toward the nose. To understand this particular reflex definitely, it should be considered from an anatomical, histological and physiological stand-point:

(a) *Anatomy*.—It will be remembered that the orbicularis palpebrarum is a sphincter muscle with its tendinous portion, including the tendo oculi, situated at the inner angle of the orbit. The muscle itself consists of two distinct portions, *i.e.*, the palpebral portion (ciliaris) covering the eyes, which is thin and pale and possesses involuntary action; and the orbicular portion (orbicularis latus) which is thick and of a reddish color and surrounds the orbit. Another distinct muscle, the tensor tarsi (Horner's muscle), a small thin muscle which arises from the orbital surface of the lachrymal bone and is inserted into the tarsal plates, plays an important rôle in this reflex. The nerves concerned are the long ciliary nerves of the cornea from the nasal branch of the trigeminus, the short ciliary branches from the ciliary ganglion, the temporal and malar branches, and the infra-orbital branch of the facial, the last innervating the tensor tarsi. The superior tarsal plate is composed of dense connective tissue and is about one-third of an inch in breadth at the centre. The free or ciliary margin

is thick and presents a perfectly straight edge. The inner angle of the plate is fixed to the margins of the orbit by the tendo oculi.

(b) *Histology*.—The cornea consists of a number of layers, the anterior being of stratified nucleated epithelium connected by delicate processes of protoplasm. Beneath the epithelium is a network of non-medullated nerves (from the ciliary) known as the subepithelial plexus, which branch into naked fibrillæ and ramify between the epithelial cells, the intra-epithelial plexus, and terminate as minute fibres with spherical end bulbs, which are exceedingly sensitive.

We now come to a physiological consideration of the tarsocorneal reflex and its clinical application. When the straight edge of the tarsal plate is pressed against the cornea, its sensitive nerve endings are irritated and a centripetal afferent impulse is conducted by the trifacial nerve to the gray matter, is there transferred and a motor impulse is sent back *via* the facial nerve to muscles which cause a lateral retraction of the lower eyelid toward the nose. A mesial contraction of the orbicularis is inevitable because the tendinous structures are situated at the internal aspect of the orbit. Also the tensor tarsi on contraction pulls the tarsal cartilages inwardly especially the inferior plate.

Variations in the reflex action are due to many causes. Narcotic drugs will diminish the excitability of the reflex arc. Neurotic individuals present an active reflex. Repeated attempts to elicit the reflex will cause fatigue and consequently a diminished or no reaction. When Horner's muscle is very indistinct, as it occasionally is, the strength of the reflex is diminished.

Lastly, the amplitude and activity of the tarsocorneal reflex diminishes directly as the depth of anæsthesia, and is therefore a valuable anæsthetic guide. The retraction of the lower lid in surgical anæsthesia (third stage) may only be  $1/64$  of an inch in amplitude. This reflex is practically as sensitive as the direct corneal produced by touching the cornea with the finger tip—a practice which is non-surgical.

*Ciliocorneal Reflex*.—This reflex is produced by causing the eyelashes of the upper lid to touch the cornea. The reaction is the same as the tarsocorneal or corneal.

*Corneal Reflex.*—The corneal reflex is essentially the same as the tarsocorneal, except that the afferent impulse is produced by direct irritation of the delicate corneal surface, usually by the point of the finger. It is bad practice to induce the reflex in this manner, as a number of corneal inflammations and ulcers have resulted from this procedure.

*Pupillary Reflex Action.*—The pupillary reactions are extremely valuable guides as to the condition of the patient during anæsthetization. In some cases the pupils are so modified by drugs, type of patient, etc., that they lose their full value as guides, but even then if interpreted correctly they serve as definite indicators of the effect of the anæsthetic.

(a) *Reaction to Light.*—When the lid is opened and the eye exposed to light, the pupil contracts. The light irritates the retina, which sends a centripetal impulse to the brain *via* the optic nerve, the efferent channel being the third nerve (ciliary ganglion and short ciliary nerves) which causes contraction of the iris. Patients with an Argyl-Robertson pupil do not react to light during narcosis, but marginal motility is present.

(b) *Marginal Motility* (Described by J. B. Morrison, *N. Y. Med. Jour.*, 1898).—During surgical anæsthesia if the eyelids are retracted and the eyes exposed there is seen an alternate non-rhythmic contraction and dilatation of the pupils. This is due possibly to a physiological battle between the third nerve, which contracts, and the irritated sympathetic (from operative manipulations) which dilates the pupil.

(c) *The crossed concomitant* pupillary reflex is produced by keeping retracted the upper eyelid of one eye while the lid of the other eye is alternately opened and closed. The pupil dilates in the exposed eye when the lid of the opposite eye is closed, and contracts when the lid is opened. This bilateral phenomenon is dependent upon the decussation of the optic nerves, and upon the activity of the reflex the depth of anæsthesia is based.

In the lighter stages of anæsthesia, the pupils are reflexly dilated from various afferent causes. During surgical anæsthesia (third stage) the pupils are contracted (unless modified by drugs, or in the persons of neurotic subjects) due to the predominating influence of the third nerve, the afferent impulses being held in abeyance to a great extent. If for some reason the patient enters the fourth stage of anæsthesia, paralytic (passive) dilatation of the pupils occurs. The differential

diagnosis between physiological reflex dilatation and pathological paralytic dilatation of the pupils is given in the following table:

| REFLEX DILATATION.   | PARALYTIC DILATATION.  |
|--|--|
| Pupil is bright, mobile, liquid, life-like hue.                          | Pupil is dull, sluggish, immobile, death-like condition.                                   |
| Other reflexes usually present.  | No reflexes of any sort present.   |
| Patient shows signs of "coming out."                                     | Entire body relaxed.   |
| Marginal motility of the iris is present.                                | No marginal motility is present.   |
| Eye-balls may roll.  | Eye-balls are fixed.   |
| Reaction of pupil to light.  | No reaction of pupil to light.   |
| Not enough anæsthetic has been given, determined by clinical experience. | Too much anæsthetic has been given, or not enough; resulting in reflex cardiac inhibition. |
| Respiration and circulation in fair condition.                           | Respiration and circulation failing.   |
| Skin has good color.   | Skin is cold and clammy; pallor or lividity.   |
| Eyelids usually closed.  | Eyelids remain partly open, due to relaxation.   |
| Tonicity of eyelids is present.  | No tonicity of eyelids.  |
| Tears are not markedly secreted.   | Increased secretion of tears.  |
| More anæsthetic will contract the pupil (third stage).                   | More anæsthetic will produce still wider dilatation, plus respiratory and cardiac arrest.  |
| Less anæsthetic will cause pupil to remain large (reflex dilatation).    | Less anæsthetic, or none, will cause the pupil to contract back to third stage.            |

(d) The *cilio-spinal* or platysma reflex is of value to determine false or spurious anæsthesia. Very often when children inhale a few breaths of anæsthetic vapor (chloroform usually) they pass at once into a natural sleep. The pupils become exceedingly small, the lid reflexes are absent, the lower jaw is relaxed, the respirations are quiet, there is general muscular relaxation, and the patient appears as if in deep anæsthesia. If an incision were made at this time the patient would cry out and immediately be wide awake, or a reflex cardiac inhibition might occur, which might prove fatal, especially if chloroform were being used. To determine this state of pseudo-anæsthesia, the patient's neck (platysma myoides) is pinched or tapped with the fingers and a pupillary reflex dilatation takes place, indicating more anæsthetic. The reflex in this case is caused by stimulation of the cilio-spinal centre, which controls the dilatation of the pupil. This centre (Budge's cilio-spinal centre) is situated in the lower cervical region, extending downward to the level of the first to third thoracic nerve.

## REFLEXES OF THE AIR PASSAGES.

These reflexes occur during the lighter stages of anæsthesia.

The *nasal* reflex is sneezing when the schneiderian membrane is irritated by a too concentrated anæsthetic vapor.

The *palatal* reflex causes gagging and swallowing movements, and often leads to vomiting.

The *pharyngeal* reflex occurs when the pharynx is irritated, the reaction being swallowing movements, or gagging.

The *laryngeal* reflex is coughing, caused by irritation of the fauces, larynx and neighboring structures.

Reflex inhibitions may also occur from this site.

"Crowing" breathing may be reflexly excited by manipulations of the surgeon in abdominal operations.

The "expiratory phase of Crile" is a grunting expiration during operations within the upper abdominal cavity, and the "inspiratory phase of Crile" is a noisy inspiration during operations in the lower abdominal cavity.

Of especial clinical interest is spasm of the glottis, with complete closure of the rima glottidis, produced reflexly by irritating vapors, usually ether, and often occurs during fairly deep anæsthesia. The stridor may persist and tongue traction be of no avail. Laryngotomy or tracheotomy may be necessary in obstinate cases. Spasm of the glottis also may be produced reflexly by afferent impulses from various parts of the body, as from the perineum. Rhythmical variations of the respiratory act may occur reflexly from various centripetal impulses, produced by the operative procedure and are of three types, viz: those that accelerate and those that inhibit respiration, and those that cause intermittent breathing.

*Rectal Reflex or Anorespiratory.*—When the rectum is dilated, the reaction produced is a sudden inspiration. The same obtains when the vagina is dilated. In any case that has entered the fourth or paralytic stage of anæsthesia, dilatation of the sphincter ani often sets the respiratory pump in action in conjunction with other means of resuscitation.

## REFLEX CARDIAC INHIBITION.

Under this heading a few important considerations relative to anæsthetics will be taken up. When a patient is in incomplete anæsthesia (particularly during chloroformization) the heart is especially susceptible to reflex inhibition, and if during this stage operations, even trivial, are begun the heart action may be arrested, and, indeed, many deaths have occurred in this manner. The principle causes of this dreaded phenomenon are afferent impulses acting reflexly upon the inhibitory fibres of the vagus; fear; irritating fumes of a concentrated chloroform vapor acting reflexly upon the sensitive mucous membrane of the air passages; directly by sudden anæmia of the medulla. Reflex cardiac inhibition is prevented by the preliminary use of atropin (this drug augments the heart beats by paralyzing the inhibitory mechanism); by a gradual administration of the anæsthetic with plenty of air; by having the patient in the third or surgical degree of anæsthesia; and by keeping the intracardiac pressure up to par. Clinically, reflex cardiac inhibition occurs most frequently when very sensitive areas are irritated, as operations about the distribution of the fifth nerve; laryngeal operations; circumcision; avulsion of the finger or toe nails; curetting a sensitive cervical canal. Care should be exercised in using the faradic current about the vagus and its branches.

## REFLEX CARDIAC ACCELERATION.

The centre for the augmentor nerves of the heart is probably situated in the bulb. Stimulation of afferent nerves in the lighter stages of anæsthesia causes a more rapid heart beat by reflexly stimulating the sympathetic nerves of the heart (providing reflex inhibition does not occur) the augmentor centre ordinarily being more easily excited than the inhibitory. The comparative pulse rate during anæsthesia is an indicator of the depth of narcosis.



## REFLEX RESPIRATORY INHIBITION AND ACCELERATION.

The same general rules apply to the respiratory action as for the cardiac action, but to a lesser degree. During the surgical procedure the pulse and respiration vary in rate, more fluctuation being present during the lighter stages of anæsthesia.

## MISCELLANEOUS REFLEXES.

*General Cutaneous.*—If the patient is too lightly anæsthetized and an incision is made, flinching occurs and disaster may result from reflex cardiac inhibition, especially when using chloroform.

*Abdominal-Peritoneal.*—The parietal peritoneum is a sensitive “signal surface,” and deep anæsthesia is often necessary to overcome the reaction, which is a rigid abdominal wall. With nitrous-oxide-oxygen anæsthesia this reflex is the surgeon’s bane, but relaxation can be greatly overcome by proper technic.

*Labiomental Reflex.*—Dastre discovered a reflex which he termed labiomental or “ultimum reflex.” He found that by irritating the upper gum (in dogs) a reflex retraction of the lower lip occurred. Perhaps this led to the well-known and valuable lip-friction, which reflexly stimulates respiration (labiorespiratory reflex). Brisk rubbing of the lips often prevents threatened anæsthetic syncope from becoming fatal.

Vomiting during anæsthesia occurs only during the lighter stages and is due to a number of causes. Ankle clonus, ether-tremor, and exaggerated knee-jerk when present are exhibited during the second stage, but had best not be classed as true reflexes.

No doubt there are many other reflex phenomena concerned in surgical anæsthesia, and it is the hope of the writer that continued scientific investigation will be conducted in this field by anæsthetists.