A PRELIMINARY REPORT ON THE INTRAVENOUS USE OF MAGNESIUM SULPHATE IN PUERPERAL ECLAMPSIA*

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IN MAY, 1924 one of the internes, Dr. E. Bogen, suggested the use of magnesium sulphate intravenously for the control of eclamptic convulsions. Having in mind the sedative action of magnesium sulphate on the nerve cells as reported by Meltzer and Auer in the American Journal of Physiology in 1904, as well as the intraspinal use of magnesium sulphate for the control of tetanic convulsions, we thought it worth while to give it a trial. Our experience in the few cases here reported has been so uniformly successful, that we feel it is worthy of further and more extensive trial and we are making this preliminary report in the hope that more extensive experience may bear out our impression that in the intravenous administration of magnesium sulphate, we have at our disposal a means, not only of controlling the convulsions of eclampsia, but an efficient treatment of the toxemia itself.

The treatment as developed at the Los Angeles General Hospital, consists of the intravenous administration of 20 c.c. of a 10 per cent solution of magnesium sulphate as soon after the first observed convulsion as possible. Eliminative measures, such as phlebotomy, stomach lavage, administration of castor oil, colonic flushings with glucose and soda are carried out as in the treatment of any toxemic condition. We are coming to feel more and more strongly, however, that the best results can be obtained by the least handling of the patient, consistent with obtaining the desired results.

The cases herewith reported are in most part from the obstetric services of Dr. L. G. McNeile, and of the writer, at the Los Angeles General Hospital. The cases were under the direct supervision of the resident obstetricians, Drs. L. J. Kaffesieder and H. White, to whom credit is due for the carrying out of the treatment. There are three cases included from the private practices of members of the attending staff.

We have now to report seventeen cases of eclampsia, ante-, intra-, and postpartal, which have received this treatment, with but one maternal death. It is to be remembered that these are all cases of the profoundly toxic type, having convulsions, and in coma when first seen, and most of whom have had little or no antepartal care.

*Read at the meeting of the Los Angeles Obstetric Society, Oct. 14, 1924.

CASE 1.—Hosp. No. 211825. Para i, twenty-six yrs., eight months pregnant, in almost continuous convulsions on admission. Two gr. ¼ doses of morphine sulphate given. Not in labor; Bl. Pr. 180. Given 20 c.c. of 10 per cent solution of magnesium sulphate intravenously on admission. Venesection of 500 c.c. 1000 c.c. of normal saline given by hypodermoclysis. Three hours later 10 c.c. of 10 per cent magnesium sulphate intramuscularly, 1000 c.c. of normal saline by hypodermoclysis repeated. Twelve hours after admission patient developed labor pains, and five hours later delivered a macerated eight months fetus. There was no further convulsion after the first injection of magnesium sulphate and recovery was uneventful.

CASE 2.—Hosp. No. 213762. Para i, eighteen yrs. Comatose when admitted, said to have had five convulsions at home. About 7½ months pregnant, not in labor. Bl, Pr. 150. Had one convulsion, immediately after being admitted. Twenty c.c. of 10 per cent solution of magnesium sulphate given intravenously during convulsion, which ceased immediately. Two hours later, patient was able to take orange juice by mouth. Two hours after admission, 10 c.c. of 10 per cent magnesium sulphate repeated intravenously; 1000 c.c. of normal saline by hypodermoclysis, patient conscious all the time. On admission there was a total anuria on catheterization for six hours. Fifteen hours after admission, developed a bloody vaginal discharge. On the supposition that a premature separation of placenta had occurred, membranes were ruptured artificially. One hour later 20 c.c. of 10 per cent magnesium sulphate given intravenously, because of extreme restlessness of patient. One and one-half hours later, spontaneous delivery of a stillborn premature infant. Recovery of mother uneventful. One of the attending obstetricians saw this patient on admission and considered her to be a hopeless case. This is one of the General Hospital series, in which any local obstetrical interference was carried out, and that only rupture of the membranes because of premature separation of placenta.

CASE 3.—Hosp. No. 212521. Para ii, age forty-two. Was in convulsions on admission. She was given 25 c.c. of 10 per cent magnesium sulphate intravenously. Morphine gr. ½ in ¼ gr. doses. One and a half hours later, 1000 c.c. normal saline by hypodermoclysis. Full term, not in labor. Had a similar attack 16 years ago. About 18 hours after admission, given Tr. veratrum viride, ♏ xv by hypo; this was followed by a drop in the blood pressure from 210/80 to 96/68. She was then given adrenalin, ♏ xv, which brought her blood pressure up to 112/78. Two hours later 10 c.c. of magnesium sulphate repeated, because of marked restlessness. The patient never came out of her coma, fully, and died undelivered of pulmonary edema twenty-four hours after admission and about six hours after administration of veratrum viride. There was no further convulsion after the first dose of magnesium sulphate.

This was the only death in the series, and in view of the drop in blood pressure following the veratrum, we feel that the pulmonary edema which closed the scene, was due as much to the veratrum, as to the toxemia itself.

CASE 4.—Hosp. No. 212813. Para i, age nineteen. In continuous convulsions on admission. At term, not in labor; 25 c.c. 10 per cent magnesium sulphate, followed by 1000 c.c. normal saline by hypodermoclysis. Ten hours after admission, 10 c.c. magnesium sulphate given, because of restlessness. Thirty-six hours after admission, spontaneous delivery of normal male infant. Recovery uneventful.

CASE 5.—Hosp. No. 212754. Para i, age eighteen. In convulsions on admission; at term, in labor, pains every ten minutes. Two convulsions after admission, 25 c.c. of 10 per cent magnesium sulphate intravenously, and gr. ¼ morphine sulphate by hypo. Patient continued in slow labor, and twenty-four hours after first injection had another convulsion while in 2nd stage labor. Magnesium sulphate 15 c.c.

given intravenously, and morphine sulphate gr. ¼. Four hours later, delivered spontaneously a normal infant. No obstetrical interference. Recovery uneventful.

CASE 6.—Hosp. No. 212431. Para vi, age thirty-five. In convulsions on admission. At term, not in labor; 20 c.c. of 10 per cent magnesium sulphate intravenously. Morphine sulphate gr. ¼ per hypo; 500 c.c. of blood by phlebotomy, two hours later, 1000 c.c. of saline by hypodermoclysis, and another gr. ¼ of morphine sulphate. Seven hours after admission convulsions recurred; 10 c.c. magnesium sulphate were then given intravenously, and convulsions ceased immediately, and did not recur. The following day she delivered spontaneously a 3½ pound stillborn infant. Mother's recovery uneventful.

CASE 7.—Hosp. No. 211127. Para ii, age twenty-one. Came in postpartum, in severe convulsion. Twenty c.c. of 10 per cent magnesium sulphate intravenously, given immediately, and gr. ½ morph. sulph. by hypo. Fisher's solution, 700 c.c. by proctoclysis. Patient continued to have convulsions. Two hours later, 15 c.c. of 10 per cent mag. sulph. intravenously and 700 c.c. 5 per cent glucose intravenously. Seven hours after admission patient was still having convulsions, and 15 c.c. of mag. sulph. were again given intravenously, and morph. sulph. gr. ¼ given by hypo. Phlebotomy of 500 c.c. Convulsions still continued, but about 36 hours after admission the coma began to clear, and the convulsions ceased. Forty-eight hours after admission, patient was conscious and made an uneventful and complete recovery from this time.

CASE 8.—Hosp. No. 210014. Para i, sixteen years of age. Delivered at 6 A. M., 4:30 P. M. convulsions began, recurring at frequent intervals until 6 P. M., 25 c.c. of 10 per cent mag. sulph. given intravenously; convulsions ceased immediately; 500 c.c. of 5 per cent glucose given intravenously and 1000 c.c. of normal saline by hypodermoclysis. Three hours later, 15 c.c. of mag. sulph. again given intravenously because of slight muscular twitching. No further convulsions, recovery uneventful.

CASE 9.—Hosp. No. 212332. Para ii, age nineteen. Admitted two days postpartum and in convulsions; 20 c.c. of mag. sulph. given intravenously, morph. gr. ¼ by hypo. Phlebotomy of 500 c.c. Convulsions ceased. Four hours later 500 c.c. normal saline by hypodermoclysis. Recovery uneventful.

CASE 10.—Hosp. No. 213687. Primipara, age twenty-six. Admitted Aug. 8, 1924; 5:15 P. M.; pains began 18 hours before admission, two convulsions before admission, Bl. Pr. 250. Had already been given morph. sulph. gr. ¼; 7 P. M. given 25 c.c. of 10 per cent mag. sulph. intravenously. No further convulsions. Pains began again at 2 A. M.. Delivered spontaneously of living baby at 8:15 A. M. Clear mentally after delivery. Uneventful convalescence.

CASE 11.—Hosp. No. 214722. Admitted Sept. 1, 1924, 10:50 A. M. Para i. Had ten convulsions before admission. Had been given 20 ♏ veratrum viride before admission. When admitted was in coma and had marked general edema. At 11:05 A. M. Bl. Pr. 150/120, was given 20 c.c. 10 per cent mag. sulph. intravenously. At 11:20 A. M. Bl. Pr. dropped to 80/50, probably as result of veratrum viride given before admission, adrenalin ♏x given, Bl. Pr. returned to 150/100 and some what later 130/100, where it remained all afternoon. At noon gastric lavage and colonic flushing with soda solution: 4:40 P. M. patient restless and crying; 20 c.c. of mag. sulph. repeated intravenously; patient quieted and went to sleep. 5 A. M. Sept. 2, 1924, patient awake and clear mentally; 1:30 P. M. membranes ruptured and bag inserted. Bl. Pr. 150/100. 9:30 P. M. labor started, 11:25 P. M. spontaneous delivery of living baby, convalescence uneventful.

CASE 12.—Private case of Drs. L. G. McNeile and J. Vruwink and reported by them. Para iii. Had had mild toxemias but no eclampsia in both her previous pregnancies, which ended in spontaneous deliveries of living babies. Due Nov. 11, 1924. July 29, 1924, Bl. Pr. 120/80 with edema. Treatment of toxemia began. Aug. 26, 1924, Bl. Pr. 195; patient sent to hospital. Aug. 29, beginning at 9 P. M. had three convulsions in rapid succession. 11 P. M. 25 c.c. of 10 per cent mag. sulph. intravenously. Two convulsions after injection. Aug. 30, 12:15 A. M. Art. rupture of membranes, 3:45 A. M. 25 c.c. of 10 per cent mag. sulph. following two more convulsions, 6 A. M. breech extraction of premature fetus. No further convulsions, convalescence uneventful.

CASE 13.—Seen by writer in consultation with Dr. C. W. Anderson, through whose courtesy I am permitted to include it in this series of cases. California Lutheran Hospital No. 83696. Para i, twenty-nine years of age, admitted Aug. 18, 1924, about 5½ months' pregnant, and in coma on admission at noon. Had had three convulsions prior to entrance. Bl. Pr. 174/90. At 12:45 P. M. seven ounces of urine obtained by catheter. 1:45 P. M. convulsion; 2:45 P. M. convulsion; 4:40 P. M. convulsion. 4:45 P. M. given first dose of mag. sulph. 20 c.c. of 10 per cent solution intravenously. Croton oil ♏2 on tongue; 8:30 P. M. Bl. Pr. 170; Phlebotomy of 600 c.c. 8:50 P. M. seventh and last convulsion; 9:20 P. M. 20 c.c. mag. sulph. intravenously; Aug. 19, 1924, 2:20 A. M. morph. sulph. gr. ¼. 2:50 A. M.; complains of tongue feeling sore; 6.50 A. M. talking plainly—10:30 A. M. colonic flushing, glucose 5 per cent, soda bicarb 2 per cent. 5 P. M. glucose and soda colonic flushing. Urinary output for 24 hours, 24½ ounces. Aug. 20, 1924, 8:30 A. M. glucose and soda colonic flushing, urinary output 54 ounces measured, not including considerable lost with bowel movements. Patient perfectly clear for first time since admission to hospital. Aug. 21, glucose and soda flushing at 4:30 P. M. Urinary output for 24 hours 67 ounces. From this time on patient was apparently well of her eclampsia, and *her pregnancy was undisturbed.* She had, however, toxemic symptoms, such as occasional blurring of vision, albumin in her urine, which had markedly diminished from 11 gms. per liter to what the laboratory termed a "moderately heavy trace"; her blood pressure remained high, from 145-154. In other words, she had been converted from a case of frank and severe eclampsia, into a preeclamptic toxemia. We had thought that she had a dead fetus as she had felt no movements for about ten days before onset of eclampsia, there had been no appreciable increase in size of the uterus and the fetal heart had not been heard; so we expected her to go into spontaneous premature labor. On Aug. 26, 27 and 28 the fetal heart was definitely heard and counted at 160 by the resident, and both Dr. Anderson and myself also heard the heart tones. On Aug. 31 her blood pressure rose to 170, and both Dr. A. and I felt that we would not be justified in attempting to carry her any further. So a bag was inserted to induce labor. She had no further medication, other than two doses of morph. sulph. gr. ⅙ in 2 c.c. of 50 per cent mag. sulph. as analgesics during her labor. Her delivery was not completed until Sept. 2, at 5:20 P. M., when a dead premature infant was delivered spontaneously, 55 hours after introduction of bag. At no time were there any convulsions during labor, her nervousness being controlled by hypodermics of morphine and magnesium sulphate. After her delivery, she had an uninterrupted convalescence, being discharged from the hospital on Sept. 8, 1924. She still carried albumin but other than this she was entirely well. Since her return home, Dr. A. informs me, the albumin has entirely disappeared.

I have reported this case in some detail as, to my mind, it is one of the most interesting of the cases, in that with two intravenous injections of magnesium sulphate, the eclamptic convulsions were stopped

and the patient's pregnancy was carried on for two weeks longer with a living fetus. It suggests the possibility of combating the remaining toxemic condition with intravenous magnesium sulphate treatment, which at this stage of our experience we did not feel justified in attempting. In studying her urinary output, we find that in the first twenty-four hours after the magnesium sulphate, she excreted 24½ ounces, the second twenty-four hours, over 54 ounces and the third twenty-four hours, 67 ounces. It would seem, then, that a partial kidney block was overcome by the action of magnesium sulphate.

CASE 14.—Hosp. No. 215-735. Admitted 10 A. M., Sept. 23, 1924. Primipara, age fifteen. About 8 months' pregnant, not in labor. Had five convulsions before admission. Bl. Pr. 180/160. Was in coma and had three convulsions before she was given the magnesium sulphate. 11:5 A. M. given 20 c.c. of 10 per cent magnesium sulphate intravenously; 11:10 A. M. convulsions stopped but patient was vomiting quantities of foul vomitus; gastric lavage done and three ounces of magnesium sulphate solution left in stomach. She then had four more convulsions and at 1:40 P. M. was again given 20 c.c. of 10 per cent mag. sulph. intravenously; during the afternoon she had four more convulsions. I saw the patient at 4:30 P. M., she was in deep coma, was markedly edematous and was apparently in a desperate condition. At 5:15 P. M. she had another dose of 20 c.c. of mag. sulph. intravenously and had one more convulsion after the last dose of magnesium sulphate. She went into labor at 7 P. M.; 8 P. M. membranes ruptured, and at 9:25 P. M. she was spontaneously delivered of a stillborn child. On Sept. 24, she was in a semicomatose condition all day; and at night, in a semicomatose delirium, she got out of bed; on the night of Sept. 25, she was partially rational, and on the morning of the 26 she had entirely cleared mentally. During the entire time of her coma she passed large quantities of urine, which could not be measured, as it was passed involuntarily. The edema disappeared rapidly. This patient had twelve observed convulsions within six hours and at least five before admission to hospital, in all seventeen in about nine hours; she received 60 c.c. of 10 per cent magnesium sulphate in six hours before the convulsions were controlled, and was not entirely clear mentally until about 70 hours after beginning of treatment. She received no other treatment than the magnesium sulphate and made an uneventful convalescence, being discharged from the hospital on Oct. 6.

CASE 15.—Hosp. No. 215-886. Admitted Sept. 25, 1924, 10:45 P. M. Age eighteen, primipara, delivered at 5:20 P. M., before admission to hospital. Two minutes after delivery had first convulsion, had had several more before being brought to hospital, including one convulsion in ambulance. Bl. Pr. on admission 166/92. At 11 P. M. was given 20 c.c. of magnesium sulphate intravenously. By midnight, patient quite rational. Gastric lavage done at 1:30 A. M. Sept. 26, 2 ounces magnesium sulphate by mouth; 4 A. M. colonic flushing, glucose and soda; 4:20 A. M. convulsion; 6 A. M. patient conscious, mag. sulph. solution 2 drams by mouth at 6 A. M., 11 A. M., 2 P. M. and 10 P. M. Patient cleared up rapidly, having no further convulsion. She was discharged from the hospital Sept. 29, at her own request. She had but one intravenous injection of magnesium sulphate, having had several postpartum convulsions before admission to hospital and only one convulsion after institution of the treatment. No further treatment given except magnesium sulphate by mouth.

CASE 16.—Hosp. No. 215-980. Admitted 5:15 P. M. Sept. 27, 1924. Age nineteen. Primipara. Was delivered at home at 5 A. M. Had had two convulsions before

delivery, which was a forceps delivery. She had a complete tear of the perineum into the rectum. She had had repeated convulsions all day and doctor in attendance had used three cans of ether and four ounces of chloroform in attempt to control convulsions. She had also had two hypodermic injections, presumably of morphine. Veratrum viride had likewise been given. On admission her Bl. Pr. was 60/40, there was a large quantity of mucus in her throat and she was very restless, throwing herself about the bed continuously. She was given adrenalin, ℥x and her Bl. Pr. went up to 110/60. At 5:40 P. M. 20 c.c. of 10 per cent mag. sulph. given intravenously, at 7:10 P. M. patient still very restless and 25 c.c. of mag. sulph. repeated. At 10:30 P. M. 20 c.c. of mag. sulph. Sept. 28, 1924, 1 A. M. morph. sulph. gr. ¼, by 7 A. M. she was able to take liquid by mouth and was given one and one-half ounces of magnesium sulphate in solution. She had no convulsion after admission to hospital, but recovered from her eclampsia only to develop a psychosis, which the psychiatrists call a dementia precox. She is still in the hospital under treatment for her mental condition. I think we are justified in claiming her as a recovery as far as her eclampsia is concerned. That she had had an operative delivery and other medical treatment is true, but that she survived the bombardment of operative attack, hypodermic medication and chloroform and ether anesthesia for twelve hours on top of her severe toxemia, is to my mind a tribute either to her powers of resistance or to the effectiveness of the eliminative powers of intravenous magnesium sulphate. If she recovers from her psychosis, she still will have to have a repair of her complete laceration.*

CASE 17.—Private case of Dr. J. C. Irvin and reported by him. Age twenty-six, para ii. Had had eight eclamptic convulsions with her first pregnancy. At that time she was delivered by vaginal hysterotomy. During her second pregnancy she was kept on a protein-free diet from the third month by her family physician. At 8½ months she began having severe headaches and blurring of vision. Eye examination revealed no changes in fundus. The following day she had a convulsion about 1 P. M. Bl. Pr. 160/90, convulsions at 3, 4, and 6 P. M. Patient seen by Dr. Irvin at 8 P. M. and she was given 2 c.c. of 50 per cent solution of magnesium sulphate intravenously. Patient quieted very much after first dose of magnesium sulphate and had no further convulsions. She was given a second dose of 2 c.c. one hour later. At 11 P. M. a classical section with sterilization was done. Twelve hours after operation patient was entirely rational and in good condition. An uninterrupted recovery was made.

In this case, the magnesium sulphate was used in much greater concentration than we have been using it, but the quantity of the drug per dose was only one-half of what we had been using. The section, I presume, was done because the patient was near term, not in labor, with a long cervix, and had already been subjected to a vaginal section, and also because of the desirability of sterilizing such a patient.

SUMMARY OF CASES

There have been eleven antepartal cases, one intrapartal and five postpartal. Of the ante- and intrapartal cases, one died undelivered; in one, membranes were ruptured artificially, with spontaneous delivery of baby; in one, at term, membranes were ruptured and bag inserted to induce labor, delivery completed spontaneously; in one, a six months' pregnancy, labor was induced by the bag after recovery from eclampsia, with spontaneous delivery of fetus; in one, a clas-

*This woman finally recovered completely from her psychosis.

sical section was done after convulsions were controlled; and in seven, spontaneous delivery without any obstetric interference.

As to the convulsions, ten were in convulsions on admission, with number of attacks unknown, one had had two convulsions; one had had three, one had had four, two had had six, one had had eight, and one had had ten convulsions before the treatment was instituted. Ten had no further convulsion after the first intravenous injection, four had one convulsion after first injection; one had two convulsions after first injection and two after second; one had four after first, four after second and one after third injection, this patient having had seventeen known convulsions before they were controlled. Three patients had but one intravenous injection of 20 c.c., 25 c.c. and 20 c.c. respectively; eight had two injections of 20 and 10 c.c.; 25 and 10 c.c.; 25 and 10 c.c.; 25 and 15 c.c.; 25 and 15 c.c; 20 and 20 c.c.; 25 and 25 c.c.; 20 and 20 c.c.; of 10 per cent solution respectively; one had two injections of 2 c.c. of 50 per cent solution; and five had three injections of 20, 10 and 20 c.c.; 20, 10 and 10 c.c.; 20, 15 and 15 c.c.; 20, 20 and 20 c.c.; and 20, 25 and 20 c.c. of 10 per cent solution respectively. Of the eleven babies which were delivered after treatment was instituted, there were five living, one full term stillborn and five premature stillborn. It will be noted that the first cases were given considerable other treatment, such as phlebotomy, saline infusion, colon flushings, etc., while the later cases, Nos. 10 to 17, had very little other treatment and were disturbed as little as possible. None of these had any hypodermoclysis and very little morphine was used in these later cases. This makes seventeen cases, with one maternal death (Case 3), a mortality of 5.88 per cent.

After this paper was completed, Dr. E. Bogen called my attention to the records of the first three cases in which magnesium sulphate had been given intravenously, hospital Nos. 207157, 209677, and 210014, which had been overlooked. Of these, two made good recoveries and one died. The one who died, the second one to receive magnesium sulphate, came in, in convulsions, and there were three convulsions before she had the magnesium sulphate; the first dose being 30 c.c. of a 3 per cent solution; nine hours later she received a second intravenous injection, this time of 20 c.c.; she was in very bad condition, her pulse varying from 136 to 160 and irregular for several hours; three-quarters of an hour after her last injection, a Scanzoni forceps delivery was done, a dead baby being delivered. Five hours after the delivery, patient had not come out of her coma, had another convulsion and died. This patient did not receive enough of the magnesium sulphate and in addition a difficult forceps extraction was done, at the height of her toxemia.

One of the others had had five convulsions before admission, and two convulsions in the ward before first injection of magnesium sul-

phate, no further convulsions. A bag was inserted to induce labor and twelve hours later she had a spontaneous delivery of a stillborn child. Uneventful recovery.

The third one had her first convulsion fourteen hours after a spontaneous delivery of a living child. She had three severe convulsions within an hour and then continuously. Her first dose of magnesium sulphate was 30 c.c. of a 7 per cent solution. She had no further convulsion, but fifteen hours later, she was given another injection of 15 c.c. of a 6 per cent solution because of muscular twitching.

We do not feel that these cases should be included as they did not receive the proper dosage and the treatment was not carried out as it has since been developed. Especially is this true of the fatal case which did not have the dosage now used, and which was *operated on at the height of her toxemia.* If we include these cases, however, there are twenty cases with a mortality of 10 per cent. The last fourteen *consecutive* cases were without mortality.

We have made a careful search of the literature in an attempt to learn if there has been any previous use of magnesium sulphate intravenously in eclampsia and also to find a logical explanation of its action. The only reference we have been able to find is an article on "Diagnosis, Prognosis and Treatment in Nephritis" by Fisher, published in the *Detroit Medical Journal,* June, 1916. In this article, he discusses the case of a patient who had a postpartum eclampsia. Fisher says, "The administration of sodium bicarbonate and of magnesium sulphate in several small doses represented a first attempt to meet the edema of her brain, that of the kidneys as expressed in her urine, and that of her tissues generally, as observed in her slight general edema." Not succeeding completely, after trying several other measures, he finally gave her intravenously, 250 c.c. of a 2 per cent solution of magnesium sulphate; this was repeated twelve hours later as "she again became drowsy and complained of headache and nausea. This was an indication to us that her brain swelling was again increasing, so a second dose of magnesium sulphate was given as before." While this observation is the basis of our work, the method of administration is very different. To take one-half hour to make an injection of 250 c.c. is feasible in a patient who is drowsy or comatose, but to do the same thing to a patient having severe convulsions in rapid succession would be rather difficult. The method as developed at the General Hospital of giving 15 to 25 c.c. of a 10 per cent solution, is very readily done in the period of relaxation immediately following a convulsion.

As stated in the beginning, our first idea was to control the convulsions by the paralyzant or sedative effect on the voluntary muscles. We were at first concerned as to whether we might not get a respiratory paralysis, but have not noted *any* deleterious effect in any of the

cases. I also believe that we get a depletant effect by withdrawing of fluids from the tissues into the blood stream, thus reducing the edema. In reducing the edema of the brain the coma clears up more rapidly and the increase of the watery elements of the blood increases the urinary output and relieves the patient of her toxins. Our results in this small series of cases have been so uniformly good that we feel that in the intravenous use of magnesium sulphate we have a method of treatment which yields results far better than any we have made use of heretofore. Our previous mortality in this class of severe eclamptics had been about 30 per cent, while in this series it was 5.8 per cent.

Without attempting to discuss the causes of eclampsia, I believe that the urgent indications for treatment are fairly definite, (1) to antidote as effectively as possible the effect of the toxins on the central nervous system; (2) to stimulate elimination of the toxins. Does the intravenous use of magnesium sulphate fulfill these indications? I believe it does.

As to its effect on the convulsions—in no case have we been unable to control the convulsions, apparently the only question being to get sufficient of the drug into the circulation to accomplish this end. This we have been able to do without any of the deleterious effects which some of the early investigators feared. In seeking an explanation of this anticonvulsive effect of the magnesium sulphate we find a considerable literature has been developed since Meltzer and Auer's original experiments were published in the *American Journal of Physiology*, October, 1905, and the *Medical Record* of Dec. 16, 1905 (quoted by Blake, *Surg. Gyn. and Obstet.*, 1906, ii, p. 541). As a result of his experiment, Meltzer concluded that "the action of the magnesium salts is distinctly inhibitory and also selective for nervous tissue." Blake, after quoting the above results of Meltzer's work, reports on the use of magnesium sulphate in production of anesthesia for surgical operations and also in the treatment of tetanus (intraspinally).

In regard to the tetanus, Blake claims "(1) A marked effect in restraining the convulsions and relieving pain, thereby conserving strength and preventing excessive metabolism and heat production. (2) That spasm of muscles of mastication and deglutition is at least lessened, thereby permitting feeding. (3) That its action is continued for a considerable period, (29 to 34 hours), without depressing action on the heart muscle; and finally, in one case at least, that repeated injections produced no harmful effect, except the inhibition of the bladder and the consequent need for catheterization." (Intraspinal use.) In the *Journal of the Am. Med. Assn.* for Oct. 14, 1916, Peck and Meltzer report on the intravenous use of magnesium sulphate for the production of anesthesia, and conclude, "The employment of intravenous injections of magnesium salt as an anesthetic may prove to be indeed a practicable and advantageous method, be-

cause, in the first place, it may cause simultaneously a *moderate relaxation of the muscular mechanism*, and secondly, because the untoward effects can be rapidly reversed by a careful administration of a solution of calcium chloride." In our work we were prepared with a solution of calcium chloride to combat any respiratory paralysis, but as already noted, fortunately, did not observe the slightest respiratory embarrassment in any of the cases.

In the *American Journal of the Medical Sciences* for March, 1923, Weston and Howard, basing their work on the reports of Meltzer and Auer, report on their use of magnesium sulphate as a sedative in excited states. They found that "In 82.7 per cent of the cases, the sedative action was prompt, the patient becoming quiet after fifteen or thirty minutes and sleeping from five to seven hours. In a few instances the patient became quiet but did not sleep. The effect persisted for from five to ten hours."

Without going any further into the extensive literature which has developed in this subject since Meltzer and Auer's original work I believe the above-quoted reports furnish an explanation of the anticonvulsive and sedative action of magnesium sulphate. As to the second therapeutic indication, viz.: elimination of the toxins, the only explanation of this action we have been able to find in the literature is in the article by Fisher, already referred to, in which he explains its therapeutic effect in this respect.

The coma usually clears comparatively rapidly, although in some of the cases it was forty-eight to seventy-two hours before the patients were entirely clear. I believe this comparatively rapid clearing-up of the coma to be due to a reduction of the edema in the brain. By the increase in the watery constituents of the blood, diuresis is increased and toxins eliminated. In other words, the magnesium sulphate in the blood stream, in addition to its anticonvulsive and sedative action, acts as it does in the bowel, namely, to withdraw tissue fluids, and instead of watery bowel movements, we have increased diuresis. This impression I have gained in particular from Case 13, in which, after the second injection of magnesium sulphate, the convulsions ceased, the coma gradually cleared; and the urinary output was 24½ ounces the first twenty-four hours, over 54 ounces the second twenty-four hours and upwards of 67 ounces the third twenty-four hours, without any considerable increase in fluid intake, and *with rapid diminution of the visible edema.* This, with the pregnancy uninterrupted.

The study of the other cases, in this particular, was not so significant, as they were all either postpartal or the delivery was completed within a short time after the treatment was begun.

As a result of our experience in this series of cases I have become more firmly convinced in my belief, which has been growing stronger

in the last few years, that eclampsia is essentially a medical complication of pregnancy and as such should be treated medically. On our services the pregnancy is not interfered with during the treatment of the eclampsia, except for some urgent obstetric indication. It has not been necessary to interfere with any of the cases, except the one with eclampsia at 5½ months and labor was induced only after the active eclampsia was entirely overcome, though the toxemic condition still existed.

From our experience, I am disposed to try the intravenous use of magnesium sulphate in cases of preeclamptic toxemia which do not improve under the usual treatment, in the hope that the toxemia can be controlled and the pregnancy carried to spontaneous labor without the supervention of an eclamptic attack. There has been observed no effect on the labor, either of hastening its onset or of interfering with its progress after it starts.

CONCLUSIONS

(1) By the intravenous use of magnesium sulphate the convulsions of eclampsia can be controlled and the coma cleared by a sufficient dosage.

(2) The intravenous use of magnesium sulphate reduces edema and promotes diuresis, thus eliminating the toxins.

(3) Other eliminative measures, such as catharsis, phlebotomy, lavage, and colonic flushings may be used as adjuvants; however, as our confidence in the magnesium sulphate has increased, we have gradually reduced this supplementary treatment until, in the last two cases, little else was done.

(4) Surgical interference with the pregnancy should not be undertaken during the eclamptic attack, except for the most urgent obstetric indication.

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