TETANUS IN NEW ORLEANS

AN ANALYSIS OF 813 CASES

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It is the purpose of this paper merely to emphasize certain important points and record statistical data on 813 cases of tetanus which have been admitted to the various surgical services of the Charity Hospital of Louisiana, at New Orleans, from 1906 to 1930. Gessner,[6] in 1918, reviewed 368 of these cases, and in 1923 Graffagnino[7] reported 596 cases, which included those previously presented by Gessner.[6] Since 1923 there have been 217 additional cases admitted to the Charity Hospital, making a total of 813 cases for consideration.

Sites of wounds.—In comparing the mortality rates (TableI) for tetanus developing from various wound sites, it will be noted that those of the upper extremities were attended with a mortality rate of 67.6 per cent. and those of the lower extremities by a mortality rate of 55 per cent. This is as would be expected, but in contradistinction to other reported series the mortality rate for five cases following wounds about the head and face was only 40 per cent., and for four cases due to infected teeth it was only 25 per cent.

TABLE I

Sites of Wounds

Site of wound	Graffagnino's series	New series	Mortality per cent new series
Lower extremities	352	111	55
Upper extremities	83	37	67.6
Head and face	32	5	40
Teeth	1	4	25
Back	9	..	..

Types of injuries.—In fifty-two cases of tetanus which developed from a nail puncture wound the mortality rate was 67.3 per cent., whereas in fifty cases in which the wound was produced by a splinter, it was only 46 per cent. In seven cases of tetanus neonatorum, in two cases of tetanus occurring post-partum, in three occurring in morphine addicts, and in six in patients who had had criminal abortions, the mortality rate was 100 per cent. (Table II).

Blank cartridge wounds deserve special comment. There were twenty-four cases of tetanus due to such wounds, and the mortality rate in these was 83.3 per cent. Certainly such a high incidence of tetanus and high mortality rate are sufficient arguments for the abolition of such a dangerous and needless method of celebrating Christmas week and Independence Day.

It is probably not generally appreciated that the wool wadding used in blank cartridges is nearly always contaminated with tetanus spores or bacilli,

TABLE II

Types of Injuries

Type of injury	Graffagnino's series	New series	Mortality per cent. new series
Splinter	163	50	46
Nail	122	52	67.3
Incised wound	44	..	..
Crushed wound	42	..	..
Brush burns	38	..	..
Tetanus neonatorum	36	7	100
Punctured wounds (excluding nails)	16	2	50
Firecrackers, blank cartridges, and airgun	23	..	..
Blank cartridges	..	24	83.3
Abortions	15	6	100
Postpartal	..	2	100
Morphine addicts	9	3	100
Compound fractures	..	2	50
Ulcer	3	1	100
Gangrene of toe	..	1	100
Amputation of stump	..	1	100
Cancer of breast—post-operative	..	1	100
Furuncle	1	..	..
Vaccination	1	..	..
Extraction of teeth	..	3	33.3
Gunshot wounds	6	3	100

as is most woolen clothing through which so many injuries are sustained. In treating wounds one is prone to associate with tetanus only those which are received in the garden or stable. There is no doubt that many clean foreign bodies carry with them tetanus spores from woolen clothing, which they penetrate to inflict an injury. Wounds received in such a manner at least deserve a débridement.

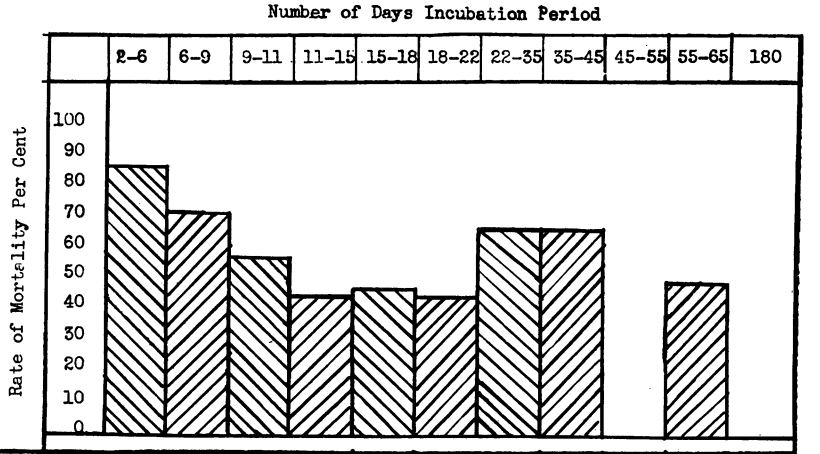
Incidence by months.—The incidence of tetanus by months in this series (Table III) is in accordance with other series in that tetanus appears to be a disease of the open season. The highest incidence was for the summer months with almost as many cases occurring in December and January. The high incidence for these two winter months is explained by the fact that in New Orleans many gunshot and blank cartridge wounds are received from Christmas Day to and through New Year's Day.

An interesting observation in this study concerning incidence of tetanus by months as shown in Table III is that for the twenty-three cases admitted in September the mortality rate was only 8.7 per cent., whereas in other months it was many times higher. There is no apparent explanation of this.

Incubation period compared with mortality rate.—In this series the lowest mortality rates occurred in those cases in which the incubation period was from ten to twenty-one days. The increase in mortality rate as shown in Chart I for cases with incubation periods of over three weeks is probably due to the presence of foreign bodies and suppuration in the wounds.

Prophylaxis and the incidence of tetanus.—Eight cases in the present

series (Chart I) had received one prophylactic dose of antitetanic serum. In only three of these was the incubation period of more than three weeks, being



		2-6	6-9	9-11	11-15	15-18	18-22	22-35	35-45	45-55	55-65	180
Cases		76	218	77	106	30	54	25	3	1	4	1
Cured		9	51	33	49	16	30	15	1	1	2	1
Died		65	157	44	47	14	24	10	2	0	2	0
Per Cent		85.5	72	57	44.3	46.6	44.4	66.6	66.6	0	50	0

CHART I.—Incubation periods with mortality rate.

twenty-eight, sixty and sixty days, respectively. Four of these eight cases died.

That a prophylactic dose of antitetanic serum will frequently prevent the development of tetanus was conclusively established in the Great War. In

TABLE III

Incidence of Tetanus by Months with Mortality Rate

Months	Cases	Discharged	Died	Mortality per cent.
January	27	6	21	77.7
February	7	5	2	28.5
March	19	7	10	52.6
April	13	6	7	54
May	15	5	10	66.6
June	21	8	13	62
July	17	10	7	41
August	27	10	17	63
September	23	21	2	8.7
October	22	10	12	54
November	7	4	3	43
December	16	4	12	75

the United States army, 1,500 units of antitetanic serum were given routinely to all wounded, and this dose was repeated after seven days whenever there was the slightest indication. Such prophylaxis,[3] in combination with proper

care of the wounds, kept the incidence of tetanus down to thirty-six cases in 224,089 wounded soldiers, or one case for each 6,224 wounded. In the Civil War, Sanford[8] states that there was one case of tetanus for each 487 wounded, or 505 cases in 246,172 wounded.

Sir David Bruce[9] reports that in 2,032,142 wounded British soldiers tetanus developed in 2,385 or in 1.17 per thousand. In October, 1914, the incidence was thirty-two for each 1,000 wounded, but in November, when the administration of antitetanic serum was begun, the incidence immediately dropped to about two per thousand and remained so throughout the war.

Prophylaxis and the incubation period.—That the administration of one prophylactic dose of antitetanic serum will greatly prolong the incubation period in those cases destined to develop tetanus is improbable. The antitoxin remains in the blood-stream approximately eight days and is then rapidly and completely excreted by about the tenth day. It is, therefore, reasonable to assume that such a prophylactic dose can only prolong the incu-

TABLE IV

Mortality Rate by Years

Period	Cases	Discharged	Died	Mortality per cent.
1840–49 (Incomplete)	16	5	11	68.7
1850–59	87	17	70	80.4
1860–69	57	14	43	75.4
1870–79	75	17	58	77.3
1880–89	81	13	68	83.9
1890–99	150	33	117	78
1900–05	101	35	66	65.3
1906–09	72	19	53	73.6
1910	33	7	26	78.8
1911	28	9	19	67.9
1912	33	8	25	75.8
1913	44	11	33	75
1914	51	15	36	70
1915	61	22	39	63.9
1916	33	13	20	60
1917	48	16	32	66.6
1918	17	7	10	58.8
1919	38	14	24	61.2
1920	44	10	34	77.3
1921	46	21	25	54.3
1922	48	19	29	60
1923	39	15	24	61.5
1924	37	13	28	75.7
1925	25	13	12	48
1926	31	24	7	22.5
1927	32	13	19	59.3
1928	29	12	17	58.6
1929	24	13	11	45.8
1840–1905	567	134	433	76.4
1906–1922	577	188	389	67.4
1923–1929	217	103	114	52

bation period for the short period that it is in the blood-stream. For this reason, the antitetanic serum should always be repeated on about the seventh day whenever a wound is a favorable one for the development of tetanus. That one prophylactic dose of serum does not greatly influence the length of the incubation period is substantiated by the fact that in 343 cases which occurred in British soldiers in France the average incubation period was, according to Cummins and Gibson,[10] 13.2 days. In the British "home hospitals," where prophylaxis was adequately repeated and where there was the influence of other factors, the average[11] incubation period was 45.5 days.

Prophylaxis and mortality rate.—That the prophylactic use of antitetanic serum lowers the mortality rate in those who develop tetanus is well established, but it is probably not generally appreciated that the proper care of the wound in which tetanus is apt to develop is more important than the administration of serum. Serum protects the individual for only a week, whereas proper and adequate care of the wound removes all possibility of the development of the infection. Many reports of cases with long incubation periods substantiate this. Débridement should be performed on all wounds in which there is a possible contamination with tetanus bacilli, and in most cases the wound should be left wide open and drainage not hindered by the application of a tight bandage.

When one compares the mortality rate of 67.4 per cent. from 1906 through 1922 with the rate of 52 per cent. from 1923 through 1929 and considers that in the former period half the cases received no antitetanic serum at all and that only eight patients were given over 50,000 units, it would seem that more adequate serum therapy in the latter period is responsible for the decrease in mortality rate. This decrease in the mortality rate is largely due to the disproportionate decrease in the number of deaths occurring in children under thirteen years of age. (Tables V and VI.)

TABLE V

Mortality Rate by Years in Children Under Thirteen Years

Period	Cases	Discharged	Died	Mortality per cent.	Cases omitted
1906–22	310	106	204	65.8	10 questionable
1923	17	5	12	70.5	
1924	20	12	8	40.0	
1925	15	11	4	26.6	
1926	21	17	4	19.0	1 tetanus neonatorum
1927	13	7	6	46.1	3 tetanus neonatorum
1928	14	7	7	50.0	
1929	13	7	6	46.1	2 tetanus neonatorum
1923–1929	113	66	47	41.5	

Tables V and VI demonstrate that the mortality rate in adults from 1906 to 1922, inclusive, was 70 per cent. or only 4.2 per cent. higher than it was in children for the same period. In this series the average dose of

TABLE VI

Mortality Rate by Years in Adults

Period	Cases	Discharged	Died	Mortality per cent.	Cases omitted
1906–1922	286	84	202	70.0	
1923	22	10	12	54.5	3 died within 8 hrs.
1924	17	1	16	94.1	1 died within 8 hrs.
1925	10	2	8	80.0	1 died within 8 hrs.
1926	10	7	3	30.0	3 died within 8 hrs.
1927	19	6	13	68.4	1 died within 8 hrs.
1928	15	5	10	66.6	
1929	11	6	5	45.4	
1923–29	104	37	67	64.4	

antitetanic serum administered was about 13,000 units per patient given serum therapy.

Antitetanic serum therapy.—Since 1923, moderately large doses of serum have been used, and the mortality rate in children has decreased from 65.8 per cent. to 41.5 per cent., whereas in the adults it has merely dropped from 70 per cent. to 64.4 per cent. The children actually received relatively larger average total doses (48,000 units) of antitetanic serum for their body weight than did the adults (average 52,400). This fact might suggest itself as the cause for the greater lowering of the mortality rate in children, but it should be recalled that the dose should not be estimated on the size of the patient, but on the amount of toxin which is thought to be in the blood-stream. In contrasting such large series as these, it is fair to assume that the virulence of foci of tetanus infections averaged about the same.

Table VII is reproduced from Graffagnino's 1906–1923 series to show in 577 cases the effects of various doses of antitetanic serum compared with those obtained without the use of serum. In this series the mortality rate for

TABLE VII

Dosage and Mortality Rate in Graffagnino's Series

Dose of serum	Cases	Discharged	Died	Mortality per cent.
501–1,000 units	4	1	3	75
1,001–10,000 units	202	68	134	66.3
10,001–20,000 units	32	9	23	71.8
20,001–50,000 units	27	10	17	63.0
50,001–100,000 units	6	2	4	66.6
Over 100,000 units	2	1	1	50.0
No serum used	304	97	207	68.0
Serum used	273	91	182	66.6

Average dosage 13,000 units

the 304 cases which did not receive antitetanic serum was 68 per cent., whereas in the 273 cases treated with serum it was 66.6 per cent. or only 1.4 per cent. lower in those who received serum therapy. As it is evident

that small doses (average 13,000 units per patient) of serum were given, a marked change in the mortality rate could hardly be expected. If it is assumed that in many instances serum therapy was given to the more severe cases, there would be less reason to expect a lowering of the mortality rate.

The mortality rates since 1923 for children on various dosages of serum are shown in Table VIII. The larger doses have not produced an unusually low mortality rate except in the eight cases which were given 90,000 to 120,000 units of antitetanic serum. All of these recovered, but this is of no great significance because of the small number of cases. In this recent series of children the average dose of antitetanic serum was 48,000 units per patient, whereas in Graffagnino's series the average was 13,000 units. In the recent series, the mortality rate was 41.5 per cent. in contrast to 65.8 per cent. in Graffagnino's series. This would seem to indicate that larger doses of antitetanic serum are distinctly of value in children.

TABLE VIII

Mortality Rates of Various Doses of Serum for Children Only from 1923 through 1929

Units of serum	Cases	Discharged	Died	Mortality per cent.
500–19,999	11	6	5	45
20,000–39,999	27	13	4	51.5
40,000–49,999	24	18	6	25.0
50,000–59,999	11	7	4	36.6
60,000–89,999	26	13	13	50.0
90,000–119,999	8	8	0	0.0
120,000–155,000	3	1	2	66.0
180,000	1	1	0	0.0
No serum used	3	0	3	100.0
	114	66	47	41.5

Average dose of serum used: 48,000 units per patient.

Examination of the hospital records reveals that in many cases 40,000 units of antitetanic serum were administered to children on admission. It is not improbable that many of the moderately severe cases improved after the administration of this dose and were, therefore, given no more serum, whereas many of the more severe cases which did not improve were given additional small doses at a time when it was too late to be effective, thus increasing the mortality rate for those receiving larger total doses. Twenty-four children were given from 40,000 to 50,000 units of antitetanic serum and of this number only six, or 25 per cent., died. Because of this favorable mortality rate, one might conclude that an initial dose of 40,000 units is probably adequate for a child who has developed a moderately severe case of tetanus after a long incubation period. But the more severe cases which develop after a short incubation period certainly should receive much larger initial doses of serum and serum therapy should be continued until there is marked symptomatic improvement.

A comparison of the adult mortality rates in this series for various dosages of antitetanic serum (Table IX) makes it evident that the amount of antitetanic serum given made little or no difference except in the nine cases receiving 120,000 or more units in which the mortality rate was only 33.3 per cent.

TABLE IX

Adult Mortality Rates and Serum Dosage

Dosage of serum	Cases	Discharged	Died	Mortality per cent.
10,000–19,999	6	1	5	83.0
20,000–39,999	23	7	16	70.0
40,000–59,999	17	10	7	41.0
60,000–89,999	25	6	19	76.0
90,000–119,999	11	3	8	72.0
120,000–149,999	6	3	3	50.0
203,000–240,000	3	3	0	0.0
No serum 1922–29	13	3	10	77.0
With serum 1922–29	104	37	67	64.4
With serum 1906–22	273	91	182	66.6
Average dosage	13,000			
No serum 1906–22	304	97	207	68.0

Average dosage: 52,400 units.

Comparison of the mortality rates of 68 per cent. for 304 adult cases which received no serum from 1906 to 1922, with that of 64.4 per cent. for 273 adult cases which received moderately large total doses of antitetanic serum (average 524,000 units per patient) suggests that serum therapy is of little or no value. But when it is recalled that the child mortality rate dropped from 65.8 per cent. to 41.5 per cent. when moderately large doses of antitetanic serum were given, it would seem that it is not the serum at fault but probably the amount given.

Examination of the hospital records suggests that frequently the initial dose of antitetanic serum given was not large enough and in many cases it was evident that the administration of serum was not repeated at all, not often enough or not soon enough.

That antitetanic serum used therapeutically greatly lowers the mortality rate in tetanus has never been conclusively proven. However, most surgeons are afraid not to use it and favorable enough statistics have been accumulated to justify its use.

Poland[12] found in the "pre-serum" days a mortality rate of 84.2 per cent. in sixty-three cases at Guy's. In 1870–71 the German military mortality rate was 90 per cent. in 350 cases.

Wainwright[4] reviewed the literature and found a mortality rate of 64 per cent. in 537 cases not treated with antitetanic serum as compared with 41 per cent. in 806 cases treated with serum.

Miller[5] reports that ninety-six cases of tetanus were admitted to the Massachusetts General Hospital since 1896. In these the mortality rate was 67.7 per cent., whereas in the twenty-five cases admitted since 1916 the mortality rate was 52 per cent. From

his five case reports it is apparent that his cases received 100,000 or more units of antitetanic serum intravenously and intraspinally.

Freelander[2] reports a mortality rate of 36 per cent. in twenty-five consecutive cases treated with massive doses of antitetanic serum given intravenously. He suggests that the average case should be given 315,000 units.

Ashhurst[1] reports a mortality rate of 38.8 per cent. in eighteen cases treated with moderately large doses of antitetanic serum given intraspinally in combination with other routes.

Stone[8] reports a mortality of 53 per cent. in forty-nine cases admitted to Los Angeles County Hospital. He advocates a total average of 125,000 units of antitetanic serum per patient to be given intraspinally and intravenously. He records a mortality rate of 35.6 per cent. for fourteen cases which received from 60,000 to 350,000 units of antitetanic serum.

Routes of administration of serum.—It is regretted that this series offers no information of value as to the best route for administration of antitetanic serum. In all cases, serum was given by the combined intravenous and intramuscular routes. In many it was given subcutaneously as well. In only thirteen was it given intraspinally and in these it was given in combination with other routes. The mortality rate in these thirteen cases was 46 per cent.

The intraspinal administration of antitetanic serum combined with other routes has been attended with good results in the small series of Ashhurst,[1] Stone,[8] and Miller,[5] but results from its use in larger series are less favorable.

Cummins and Gibson,[10] in reporting statistics on British army patients with tetanus in France, found a mortality rate of 68.2 per cent. for 360 cases treated intrathecally alone or in combination with other routes as compared with 64.5 per cent. for 164 cases not treated intrathecally.

Bruce,[9] in a report on tetanus infection which occurred in British "home hospitals," found a mortality rate of 32.9 per cent. for 804 cases treated intrathecally alone or in combination with other routes as compared with 20.8 per cent. for 585 not treated intrathecally.

Wainwright,[4] in an analysis of cases collected by questionnaire, found a mortality rate of 61.7 per cent. for 243 cases treated intrathecally alone or in combination with other routes as compared with 52.2 per cent. for 297 not treated intrathecally.

SUMMARY

A total of 813 cases of tetanus are reviewed with a more detailed study of the 217 cases which recently have been admitted to the Charity Hospital of Louisiana.

In this series it is found that tetanus developed more frequently from wounds of the lower extremities than from wounds of the upper extremities, but that the mortality rate was 12.6 per cent. higher in the latter group.

Of the common wounds the highest incidence occurred in nail puncture wounds which were attended by a mortality rate of 67.3 per cent. This mortality rate was only 16 per cent. lower than that which occurred in twenty-four cases of tetanus which developed from blank cartridge wounds. In seven cases of tetanus neonatorum and the few cases developing postpartum, in morphine addicts, and after abortions, the mortality rate was 100 per cent.

More cases of tetanus occurred in the summer than in the spring and fall, but in contradistinction to other reported series the months of December and January had a high incidence due to the many gunshot and blank cartridge wounds which were received during the Christmas holidays. For no apparent reason twenty-three cases admitted in September had a mortality rate of only 8.2 per cent.

The greatest number of cases of tetanus developed after incubation periods of from six to fifteen days, and the lowest mortality rate occurred in those cases developing after incubation periods of from ten to twenty-one days. Four deaths occurred in eight cases which had received prophylactic doses of antitetanus serum.

The importance of repeating the prophylactic dose of antitetanic serum every seven days is emphasized as it has been found that antitetanic serum protects the patient likely to develop tetanus only for the eight to ten days that it remains in the blood-stream.

The Charity Hospital mortality rates in tetanus by years are shown not to have varied markedly from 1840 to 1922. From 1840 to 1905, when antitetanic serum was administered to only a few cases, the mortality rate was 76.4 per cent., whereas in 577 cases admitted from 1906 to 1922, inclusive, it was 67.4 per cent. Of this latter group only 273 patients were given antitetanic serum (average dose 13,000 units). From 1923 to 1929, the mortality rate decreased to 52 per cent. for 217 patients who were given moderately large doses of antitetanic serum (average dose 50,000 units). This decrease in mortality rate for the latter group is occasioned by a disproportionate decrease in the mortality rate in children.

From 1906 to 1922, inclusive, the mortality rate in 310 cases of tetanus which occurred in children under thirteen years of age was 65.8 per cent., or only 4.2 per cent. lower than for 286 adults during the same period. But from 1923 to 1929, inclusive, the child mortality rate in 113 cases was 41.5 per cent., whereas in 104 cases in adults it was 64.4 per cent. The average amount of antitetanic serum administered to adults was 52,400 and to children 48,000 units. These dosages at first seem disproportionate, but it is not the size of the patient but the amount of toxin in the blood-stream which should determine the dose.

Considering this marked decrease in the child mortality rate since moderately large doses of antitetanic serum have been used, it is apparent that adequate antitetanic serum therapy is of distinct value in the treatment of tetanus in children. Because there were only six deaths in the twenty-four cases in children which were given total doses of 40,000 to 60,000 units of serum, it seems that an initial dose of 40,000 units of serum should be adequate for the cure of many of the moderately severe cases in children.

In the adult cases the mortality rate was not greatly influenced by any particular amount of antitetanic serum administered, although the rate was only 33.3 per cent. for the nine cases which received more than 119,000 units of serum.

All cases in the recent series received antitetanic serum by the combined intramuscular and intravenous routes. Not infrequently the subcutaneous route was used in addition. The intraspinal route alone was not used in any case, but it was combined with other routes in thirteen cases, of which six died.

CONCLUSIONS

Wounds of the lower extremities cause more cases of tetanus than those of the other parts of the body, but the mortality rate is lowest in the cases developing from wounds of the lower extremities.

Of all common wounds in which tetanus developed those produced by nails were attended with the highest mortality rate.

Because of the many blank cartridge wounds resulting in tetanus with an associated mortality rate of 83.3 per cent. in this series, it is thought that such a needless and dangerous method of celebrating should be abolished.

Tetanus is a disease of the open season.

The lowest mortality rate in tetanus is for the cases which have incubation periods of from ten to twenty-one days.

Prophylactic doses of antitetanic serum lower the incidence of tetanus and lower the mortality rate in those that develop tetanus.

Because of the many cases that develop after long incubation periods, it is thought that wounds should be more skillfully attended to and that prophylactic doses of antitetanic serum should be repeated every seven days as long as there is a possibility that tetanus infection might develop.

Because of the marked difference in the mortality rates in children and adults in this series, one might be justified in concluding that antitetanic serum is of more therapeutic value in children than it is in adults.

An initial dose of 40,000 units of antitetanic serum is adequate for many of the moderately severe cases of tetanus in children, but because it is difficult to estimate the amount of toxin that is and will be in the blood-stream, and because all cases do not improve on 40,000 units of antitetanic serum, it is thought that all children who have not an obviously mild case of tetanus should receive, as early as possible, an initial dose of 80,000 units of antitetanic serum. Such a dose would frequently obviate the need for administering additional doses at a less favorable time.

In this series the mortality rate is high for adults receiving moderately large doses of antitetanic serum. The amount of serum used was often inadequate and was frequently administered too late. For these reasons, it is thought that massive initial doses should be administered as early as possible. Because the cost of massive doses is usually prohibitive ($3.50 per 10,000 units) a compromise of not less than 100,000 units of antitetanic serum is advocated as an initial dose for all adult cases of tetanus which are not obviously mild.

Even if symptomatic improvement occurs after the administration of large initial doses of antitetanic serum, it seems advisable to repeat doses

of 10,000 to 30,000 units of antitetanic serum for from three to five days or more.

If no symptomatic improvement follows the administration of large initial doses of serum, the patient should most certainly be given repeated doses of 50,000 to 100,000 units of antitetanic serum.

No conclusions can be drawn from the intraspinal administration of serum to patients in this series. However, the administration of antitetanic serum by the combined intravenous and intramuscular routes to children of this series has been attended by a mortality rate that compares favorably with any reported series. After a review of large series in the literature, it cannot be definitely concluded that administration of antitetanic serum intraspinally offers any advantage.

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