Resuscitation tables: a useful tool in calculating pre-burns unit fluid requirements

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ABSTRACT

Background: There is considerable variation in the standard of initial burn management, particularly burn surface area assessment and application of resuscitation formulae. Early aggressive management of major burns improves survival. Internationally, the Parkland formula employing lactated Ringer's solution is used for fluid resuscitation. This study aimed to assess whether Parkland fluid resuscitation tables could improve the accuracy of initial fluid requirement calculations.
Methods: The burn size had first to be determined for an adult and a child using a preshaded Lund and Browder chart. Fluid requirements then had to be calculated using the conventional Parkland formula. The burn size had to be similarly calculated for two further cases and fluid requirements calculated using resuscitation tables. The study had a sample size of 50, consisting of plastic surgery trainees, anaesthetists and burn nurse specialists.
Results: All the participants found the resuscitation tables to be quicker and easier to use. The burn size was correctly calculated in 72% of cases. Fluid resuscitation requirements were correct in only 55% when using the Parkland formula. The use of resuscitation tables improved the accuracy in calculating fluid requirements to 75%.
Conclusions: The use of Parkland fluid resuscitation tables can improve accuracy and ease of calculation of fluid resuscitation requirements.

There is considerable variation in the standard of initial burn management, particularly assessment of burn surface area and application of resuscitation formulae.[1–4] It is well known that the early aggressive management of major burns improves survival. Internationally, the standard for fluid resuscitation in major burns is now accepted to be the use of the Parkland formula using lactated Ringer's solution (Hartman's solution).[5] This has been our standard practice since 1997. Although our Burns Centre treats an average of 30 resuscitation burns per annum, most emergency departments may only see an average of 1.5 resuscitation-sized burns per year. Consequently, emergency department junior medical staff and nurses are unlikely to be experienced in the assessment and initial management of a major burn. They are expected to estimate the patient's weight (accurate weight determination is often difficult in emergency departments[4]), assess the burn surface area (using a Lund and Browder chart) and then, using the Parkland formula, calculate the amount of fluid required to resuscitate the patient. This study aimed to assess whether Parkland fluid resuscitation tables with pre-calculated values could improve the accuracy and ease of calculation of the initial fluid requirements.

METHODS

In our Burns Centre we use the Parkland formula to calculate the total fluid requirement in the first 24 h. For adults this is equal to:

4 ml × [total burn surface area (%)] × [body weight (kg)]

Half of the calculated amount is given in the first 8 h and the rest is given over the next 16 h.

For children, a modified Parkland formula is used in which the total fluid requirement in 24 h is equal to:

3 ml × [total burn surface area (%)] × [body weight (kg)]

Half of this is given in the first 8 h and the rest over the next 16 h.

Children also receive maintenance fluid (dextrose saline) at an hourly rate of 4 ml/kg for the first 10 kg body weight plus 2 ml/kg for the second 10 kg body weight plus 1 ml/kg for >20 kg of body weight.

We designed a resuscitation table based on the Parkland formula, with body weight in kilograms along one axis and percentage burn surface area along the other axis (fig 1). By simply checking these two variables on the table, two pre-calculated values are supplied: a flow rate (ml/h) for the first 8 h and a flow rate for the following 16 h. Insensible losses in adults were not taken into account as this can vary according to the circumstances. A modified table for children weighing <36 kg was also devised (fig 2). This table included normal paediatric maintenance fluid requirements in the pre-calculated flow rate values.

In order to compare the use of the conventional Parkland formula with the use of the resuscitation tables in calculating fluid requirements, we designed a calculation test (fig 3). First, questions were asked about burn sizes in adults and children requiring fluid resuscitation, choice of fluid and correct formula. Then followed four cases in which the burn size had to be determined for an adult and a child using a preshaded Lund and Browder chart. Fluid requirements then had to be calculated using the Parkland formula. The burn size had to be similarly calculated for two further cases, but this time the fluid requirements had to be calculated with the aid of resuscitation tables.

Plastic surgery trainees, anaesthetists and burns specialist nursing staff were selected to complete the test. They were asked to take the test under examination conditions with a maximum time of 20 min allowed for completion. They had access only to a calculator and also had no prior knowledge of the test.

Figure 1 Parkland resuscitation table for adults.

Parklands resuscitation formula for adults

Body Wt (kg) \ % Burn	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
40	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950
	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475
45	113	169	225	281	338	394	450	506	563	619	675	731	788	844	900	956	1013	1069
	56	84	113	141	169	197	225	253	281	309	338	366	394	422	450	478	506	534
50	125	188	250	313	375	438	500	563	625	688	750	813	875	938	1000	1063	1125	1188
	63	94	125	156	188	219	250	281	313	344	375	406	438	469	500	531	563	594
55	138	206	275	344	413	481	550	619	688	756	825	894	963	1031	1100	1169	1238	1306
	69	103	138	172	206	241	275	309	344	378	413	447	481	516	550	584	619	653
60	150	225	300	375	450	525	600	675	750	825	900	975	1050	1125	1200	1275	1350	1425
	75	113	150	188	225	263	300	338	375	413	450	488	525	563	600	638	675	713
65	163	244	325	406	488	569	650	731	813	894	975	1056	1138	1219	1300	1381	1463	1544
	81	122	163	203	244	284	325	366	406	447	488	528	569	609	650	691	731	772
70	175	263	350	438	525	613	700	788	875	963	1050	1138	1225	1313	1400	1488	1575	1663
	88	131	175	219	263	306	350	394	438	481	525	569	613	656	700	744	788	831
75	188	281	375	469	563	656	750	844	938	1031	1125	1219	1313	1406	1500	1594	1688	1781
	94	141	188	234	281	328	375	422	469	516	563	609	656	703	750	797	844	891
80	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900
	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950
85	213	319	425	531	638	744	850	956	1063	1169	1275	1381	1488	1594	1700	1806	1913	2019
	106	159	213	266	319	372	425	478	531	584	638	691	744	797	850	903	956	1009
90	225	338	450	563	675	788	900	1013	1125	1238	1350	1463	1575	1688	1800	1913	2025	2138
	113	169	225	281	338	394	450	506	563	619	675	731	788	844	900	956	1013	1069
100	250	375	500	625	750	875	1000	1125	1250	1375	1500	1625	1750	1875	2000	2125	2250	2375
	125	188	250	313	375	438	500	563	625	688	750	813	875	938	1000	1063	1125	1188
105	263	394	525	656	788	919	1050	1181	1313	1444	1575	1706	1838	1969	2100	2231	2363	2494
	131	197	263	328	394	459	525	591	656	722	788	853	919	984	1050	1116	1181	1247
110	275	413	550	688	825	963	1100	1238	1375	1513	1650	1788	1925	2063	2200	2338	2475	2613
	138	206	275	344	413	481	550	619	688	756	825	894	963	1031	1100	1169	1238	1306
115	288	431	575	719	863	1006	1150	1294	1438	1581	1725	1869	2013	2156	2300	2444	2588	2731
	144	216	288	359	431	503	575	647	719	791	863	934	1006	1078	1150	1222	1294	1366
120	300	450	600	750	900	1050	1200	1350	1500	1650	1800	1950	2100	2250	2400	2550	2700	2850
	150	225	300	375	450	525	600	675	750	825	900	975	1050	1125	1200	1275	1350	1425

(dark grey)	x ml/hr over 1st 8 hours
(light grey)	x ml/hr over next 16 hours

RESULTS

The study had a sample size of 50, consisting of 25 plastic surgery trainees, 15 anaesthetists and 10 burns nurses. Sixteen (32%) did not know the correct burn size percentages for adults and children that require fluid resuscitation and 11 (22%) did not know that Hartman's solution is the preferred crystalloid for resuscitation. Only three (6%) did not know that the Parkland formula was the correct formula for calculating fluid requirements.

All 50 participants found the tables quicker and easier to use than the conventional use of the Parkland formula. The burn size was correctly calculated in 144 of the 200 cases (72%) in both groups.

When assessing the accuracy of the calculations, any initially incorrectly assessed burn size was ignored to enable comparison of the two calculation methods. A correct answer was awarded if the calculated value fell within 10 ml/h (arbitrary) of the correct value.

Adults

Case 1

Burn as percentage of total body surface area = 25%.

Using the Parkland formula:

First 8 h: correct rate = 500 ml/h

There were 31 correct and 19 wrong answers; the lowest calculated rate was 300 ml/h and the highest was 700 ml/h; 10 cases were over the correct rate, 5 cases were under and in 4 cases no answer was given.

Parklands resuscitation formula for children (<36 kg)

Body Wt (kg) \ % Burn	8	10	12	14	16	18	20	23	25	28	30	35	40	45	50	55	60	65	70	75	80	85	90
4	24	26	28	30	32	34	36	39	41	44	46	51	56	61	66	71	76	81	86	91	96	101	106
	20	21	22	23	24	25	26	27	29	30	31	34	36	39	41	44	46	49	51	54	56	59	61
5	29	33	35	38	40	43	45	48	51	54	58	64	70	76	83	89	95	101	108	114	120	126	133
	25	26	28	29	30	31	33	34	36	37	39	42	45	48	51	54	58	61	64	67	70	73	76
6	35	39	42	45	48	51	54	58	62	65	69	77	84	92	99	107	114	122	129	137	144	152	159
	30	32	33	35	36	38	39	41	43	45	47	50	54	58	62	65	69	73	77	80	84	88	92
7	41	46	49	53	56	60	63	67	72	76	81	89	98	107	116	124	133	142	151	159	168	177	186
	35	37	39	40	42	44	46	48	50	52	54	59	63	67	72	76	81	85	89	94	98	102	107
8	47	52	56	60	64	68	72	77	82	87	92	102	112	122	132	142	152	162	172	182	192	202	212
	40	42	44	46	48	50	52	55	57	60	62	67	72	77	82	87	92	97	102	107	112	117	122
9	53	59	63	68	72	77	81	87	92	98	104	115	126	137	149	160	171	182	194	205	216	227	239
	44	47	50	52	54	56	59	61	64	67	70	75	81	87	92	98	104	109	115	120	126	132	137
10	59	65	70	75	80	85	90	96	103	109	115	128	140	153	165	178	190	203	215	228	240	253	265
	49	53	55	58	60	63	65	68	71	74	78	84	90	96	103	109	115	121	128	134	140	146	153
11	63	70	75	81	86	92	97	104	111	118	125	138	152	166	180	193	207	221	235	248	262	276	290
	52	56	59	61	64	67	70	73	76	80	83	90	97	104	111	118	125	131	138	145	152	159	166
12	67	74	80	86	92	98	104	112	119	127	134	149	164	179	194	209	224	239	254	269	284	299	314
	55	59	62	65	68	71	74	78	82	85	89	97	104	112	119	127	134	142	149	157	164	172	179
14	74	83	90	97	104	111	118	127	136	144	153	171	188	206	223	241	258	276	293	311	328	346	363
	61	66	69	73	76	80	83	87	92	96	101	109	118	127	136	144	153	162	171	179	188	197	206
16	82	92	100	108	116	124	132	142	152	162	172	192	212	232	252	272	292	312	332	352	372	392	412
	67	72	76	80	84	88	92	97	102	107	112	122	132	142	152	162	172	182	192	202	212	222	232
18	90	101	110	119	128	137	146	157	169	180	191	214	236	259	281	304	326	349	371	394	416	439	461
	73	79	83	88	92	97	101	107	112	118	124	135	146	157	169	180	191	202	214	225	236	247	259
20	98	110	120	130	140	150	160	173	185	198	210	235	260	285	310	335	360	385	410	435	460	485	510
	79	85	90	95	100	105	110	116	123	129	135	148	160	173	185	198	210	223	235	248	260	273	285
22	103	117	128	139	150	161	172	186	200	213	227	255	282	310	337	365	392	420	447	475	502	530	557
	83	90	95	101	106	112	117	124	131	138	145	158	172	186	200	213	227	241	255	268	282	296	310
24	109	124	136	148	160	172	184	199	214	229	244	274	304	334	364	394	424	454	484	514	544	574	604
	87	94	100	106	112	118	124	132	139	147	154	169	184	199	214	229	244	259	274	289	304	319	334
26	115	131	144	157	170	183	196	212	229	245	261	294	326	359	391	424	456	489	521	554	586	649	651
	90	99	105	112	118	125	131	139	147	155	164	180	196	212	229	245	261	277	294	310	326	342	359
28	121	138	152	166	180	194	208	226	243	261	278	313	348	383	418	453	488	523	558	593	628	663	698
	94	103	110	117	124	131	138	147	156	164	173	191	208	226	243	261	278	296	313	331	348	366	383
30	126	145	160	175	190	205	220	239	258	276	295	333	370	408	445	483	520	558	595	633	670	708	745
	98	108	115	123	130	138	145	154	164	173	183	201	220	239	258	276	295	314	333	351	370	389	408
32	132	152	168	184	200	216	232	252	272	292	312	352	392	432	472	512	552	592	632	672	712	752	792
	102	112	120	128	136	144	152	162	172	182	192	212	232	252	272	292	312	332	352	372	392	412	432
34	136	157	174	191	208	225	242	263	285	306	327	370	412	455	497	540	582	625	667	710	752	795	837
	104	115	123	132	140	149	157	168	178	189	200	221	242	263	285	306	327	348	370	391	412	433	455
36	144	166	184	202	220	238	256	279	301	324	346	391	436	481	526	571	616	661	706	751	796	841	886
	110	121	130	139	148	157	166	177	189	200	211	234	256	279	301	324	346	369	391	414	436	459	481

x ml/hr over 1st 8 hours (dark grey rows)

x ml/hr over next 16 hours (light grey rows)

NB: the above fluid volumes include maintenance volumes per hour

Figure 2 Parkland resuscitation table for children (<36 kg).

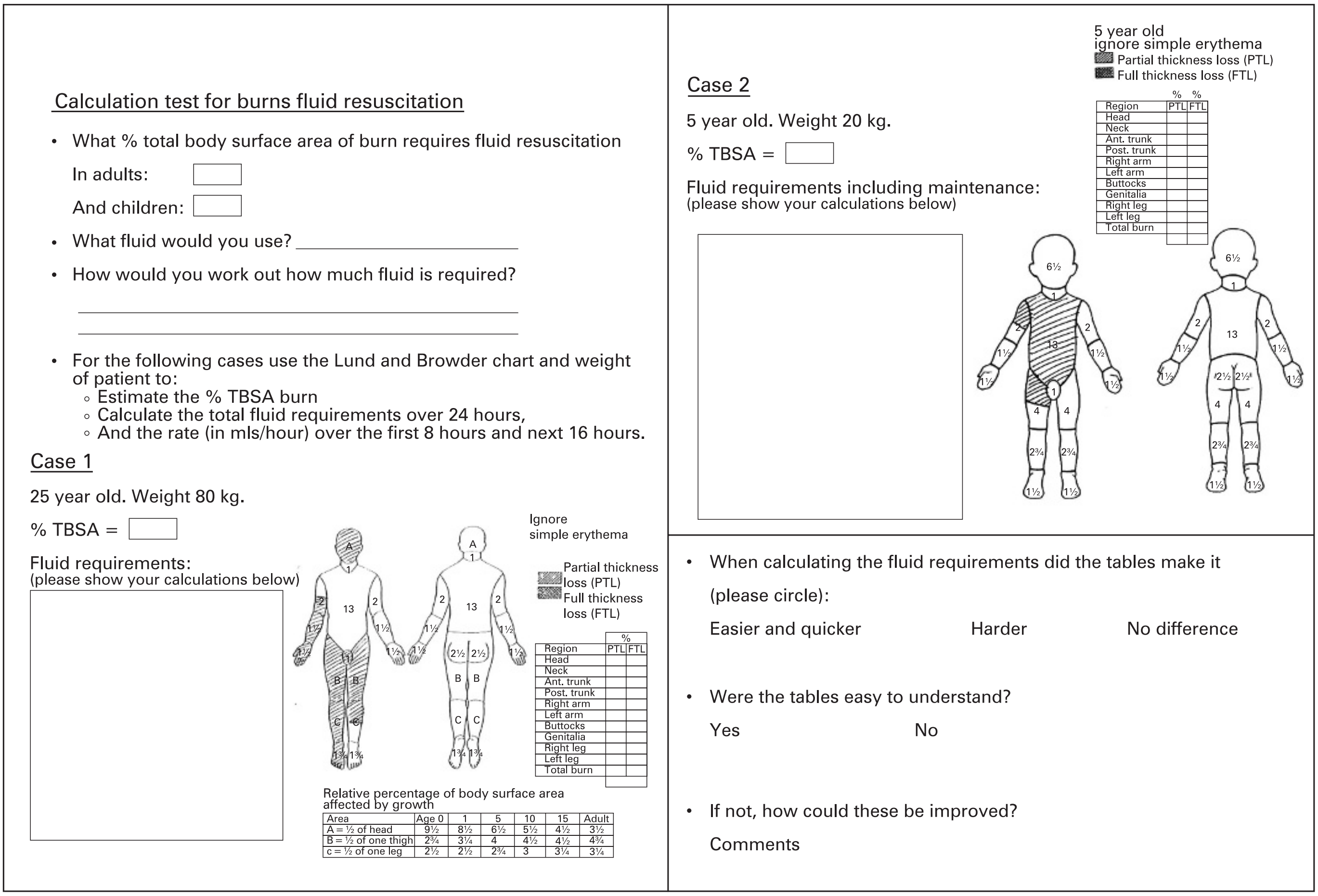

Figure 3 Calculation test: sample page. TBSA, total body surface area.

Case 3

Burn as percentage of total body surface area = 20%.

Using resuscitation table:

First 8 h: correct rate = 350 ml/h

There were 41 correct and 9 wrong answers; the lowest calculated rate was 175 ml/h and the highest was 788 ml/h; 6 cases over, 2 cases under and in one case no answer was given.

Children

Case 2

Burn as percentage total body surface area = 16%.

Using Parkland formula:

First 8 h: correct rate = 120 ml/h

There were 19 correct and 31 wrong answers; the lowest calculated rate was 40 ml/h and the highest was 240 ml/h; 17 cases over, 12 cases under and in 2 cases no answer was given.

Twenty-five of the 31 wrong answers included incorrect maintenance fluid calculations.

Case 4

Burn as percentage total body surface area = 23%.

Using resuscitation table:

First 8 h: correct rate = 135 ml/h

There were 35 correct and 15 wrong answers; the lowest calculated rate was 48 ml/h and the highest was 166 ml/h; 5 cases over and 10 under.

Calculation of fluid resuscitation requirements when using the Parkland formula was correct in only 50 of the 100 (50%) adult and child cases. This total included only 19 (38%) correct answers for the 50 child cases and 31 (62%) correct answers for the 50 adult cases. The use of resuscitation tables, however, improved the accuracy in calculating fluid requirements in 76 of the 100 adult and child cases (76%). This included 35 (70%) correct answers for the 50 child cases and 41 (82%) correct answers for the 50 adult cases.

We compared these two calculation methods using the χ^2 test. This revealed that the results for both adults and children were significantly ($p<0.05$) better when using the resuscitation tables.

When using the Parkland formula to determine fluid requirements in children, difficulty arose when calculating the maintenance fluid requirements.

Many participants noted that a common problem encountered when using the resuscitation tables was if a burn size or weight value fell between two adjacent values on an axis. A way of avoiding this problem would be to have ranges of values along both axes.

DISCUSSION

The study has shown that the use of our resuscitation tables appears to make calculating fluid requirements quicker and easier resulting in improved accuracy, particularly in children.

Our study has also revealed that, rather surprisingly, even among more specialist personnel, certain fundamental facts about fluid resuscitation do not seem to be clear. One-third of participants did not know what burn sizes warrant formal fluid resuscitation and one-fifth did not know which fluid is most appropriate for resuscitation.

Immediate burn care involves airway management and fluid resuscitation, the most important period being the first few hours after the burn injury.[6 7] On admission to the emergency department the total body surface area percentage burn should be assessed and the time of injury must be obtained. If the burn is assessed as <15% (10% in children), oral fluids alone will suffice, presuming no other concomitant injury requiring fluid resuscitation has been sustained. With burns greater than these values, intravenous replacement is needed. All these patients should have a urinary catheter for monitoring of adequate replacement. The aim of resuscitation is to maintain a urine output of 0.5–1.0 ml/kg/h in adults and 1.0–1.5 ml/kg/h in children.

The starting point for resuscitation is the time of injury, not the time of admission. There is no ideal fluid resuscitation regimen and all formulae are only guidelines. Their success relies on adjusting the amount of fluid administered against monitored physiological (urine output, pulse, blood pressure and respiratory rate) and non-physiological (humidity and environmental temperature) parameters.

The main aim of resuscitation is to maintain tissue perfusion to the zone of stasis and so prevent the burn deepening. Too little fluid will cause hypoperfusion, whereas too much will lead to oedema resulting in tissue hypoxia. In children, in particular, there is a non-linear relation between body surface area and weight. This has led to the under resuscitation of small burns and the overhydration of those with larger burns.[8]

Major burns are uncommon in the UK and, as most patients with burns will initially be managed in an emergency department, staff may lack experience in their management.

Other methods have previously been designed to help in calculating fluid requirements such as the Burns calculator[9 10] and the Burn wheel.[11] We would like to propose the use of our even simpler Parkland fluid resuscitation tables to improve accuracy and ease of calculation of fluid resuscitation requirements. Medical and nursing staff without burns experience should find these tables very helpful in determining quickly and easily the correct amount of fluid needed to resuscitate a patient with burns.

We acknowledge that there are limitations to the use of these tables in a patient with burns requiring fluid resuscitation who presents late. In this case the burns resuscitation tables will not be appropriate for the calculation of the fluid resuscitation regimen.

We would also like to encourage attendance by specialists and non-specialists at courses such as the Emergency Management of Severe Burns Course to improve their general understanding of the acute management of burn injuries.

All major burns need to be discussed at the earliest possible stage with the regional burns centre to facilitate further management of the patient. The burns resuscitation tables, however, will allow more accurate and appropriate fluid resuscitation in the emergency department before referral and transfer of the patient.

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