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Laparoscopic Surgery Contributes to Global Warming

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ABSTRACT

Carbon dioxide (CO_2), the most important greenhouse gas, is indispensable for laparoscopic surgery. We hypothesize that the amount of CO_2 released into the atmosphere worldwide during laparoscopic surgery contributes significantly to global warming. To assess CO_2 emissions, we first determined the number of laparoscopic operations performed in Japan from 1990 through 2007. Then we measured the quantity of CO_2 used at our institution. We found that in 2007 more than 35.384 t of CO_2 were used for laparoscopic surgery in Japan. More than 232.11 t of CO_2 were used from 1990 through 2007. About 90% of the CO_2 was released into the atmosphere. Extrapolating from Japan to the entire industrialized world indicates that a large amount of CO_2 is released into the atmosphere during laparoscopic surgery. The amount is likely to increase in the future. We recommend that surgeons should use CO_2 conservatively during laparoscopic surgery to help reduce global warming. Also research and development on alternative gasses are encouraged.

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Key word : global warming, carbon dioxide, laparoscopic surgery, greenhouse gas, climate change

INTRODUCTION

Carbon dioxide and other greenhouse gases produced by human industrial activity are major contributors to global warming[1,2]. Under the Kyoto Protocol, 159 industrialized countries have agreed to reduce their collective emissions of greenhouse gases by 5.2% from the levels emitted in 1990[3]. Both industry and individuals are making efforts to reduce CO_2 emissions[4,5]. In contrast, surgeons who use laparoscopic procedures are increasing CO_2 emissions. Laparoscopic surgery, which began to spread rapidly in the 1990s, requires the use of CO_2 to expand the abdominal cavity to provide space for visualization and instrumentation. Although a small amount of the CO_2 is absorbed by the patient's tissues, by the end of the procedure almost all of the CO_2 is released into the atmosphere.

We hypothesize that the amount of CO_2 released into the atmosphere worldwide during laparoscopic surgery contributes significantly to global warming. As a step toward determining this contribution, we assessed the amount of CO_2 used in Japan during laparoscopic surgery from 1990 through 2007.

MATERIALS AND METHODS

To calculate the amount of CO_2 used during laparoscopic surgery in Japan from 1990 through 2007, we multiplied the total number of cases performed for each type of

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laparoscopic surgical procedure each year by the mean amount of CO_2 used during a single such laparoscopic procedure (in liters) and then calculated the total amounts.

We calculated the total number of laparoscopic surgical procedures performed in Japan from 1990 through 2007 from data in the "National Questionnaire Survey on Laparoscopoic Surgery," which was obtained by the Japanese Society for Endoscopic Surgery in 2008[6]. This survey included responses from 1,202 of the 2,364 institutions (50.8%) in Japan. We believe that these responses accurately reflect the number of laparoscopic surgical procedures performed throughout Japan from 1990 to 2007 because the institutions that responded to the survey account for about 90% of the laparoscopic procedures performed in Japan[6].

We determined the mean amount of CO_2 used during each type of laparoscopic procedure both alone and with accompanying actions. The amount of CO_2 used during each type of laparoscopic procedure performed in gastroenterologic surgery and in pediatric surgery were determined by prospectively noting the amount of CO_2 used during each laparoscopic procedure performed in the Department of General Surgery and the Department of Pediatric Surgery in our institution for 3 months. In addition, we noted the amount of CO_2 used during 3 actions that accompany several of these procedures : ligation, release of the mist generated by using an ultrasonically activated scalpel, and hand-assisted laparoscopic surgery. The amount of CO_2 used during each type of laparoscopic procedure performed in the Department of Gynecology and the Department of Urology was estimated on the basis of the amounts used in laparoscopic procedures of a similar type and duration performed in the Department of General Surgery and the Department of Pediatric Surgery[7–10]. We then used these amounts to calculate the amounts of CO_2 used throughout Japan from 1990 through 2007.

After calculating the amount of CO_2 used for each type of laparoscopic procedure, we translated the amount in liters into tonnes using the following conversions : 22.4 L CO_2=1 mol ; 1 mol=44 g. Finally, since about 10% of the CO_2 used during laparoscopic surgery is absorbed by the patient's tissues, we estimated that 90% is released into the atmosphere[11,12].

RESULTS

The total number of laparoscopic abdominal, pediatric, gynecologic, and urologic surgical procedures performed in Japan from 1990 through 2007 was more than 634,295 (449,510, 13,519, 144,648, and 26,618) (Table 1). The number of laparoscopic procedures performed in 2007 alone was 77,227.

For the 4 main laparoscopic procedures, mean perioperative CO_2 use in our institution was 83 L per procedure for cholecystectomy, 505 L for fundoplication, 19 L for herniorrhaphy, and 290 L for gastrectomy (Table 2).

For the accompanying actions, mean perioperative CO_2 use in our institution was 3.8 L for extracorporeal ligation (defined as 1 ligature tied 3 times), 2.4 L for manual release of mist from the port, 7.7 L for automatic release of mist from the port after 30 seconds of cutting with an ultrasonically activated scalpel to divide the greater omentum, and 4.9 L for hand-assisted laparoscopic surgery, because when the surgeon inserts his hand, CO_2 escapes and is automatically replaced (Table 3).

The amounts of CO_2 used in Japan during each type of surgical laparoscopic procedure for each surgical specialty are shown in Tables 4–7.

The total amount of CO_2 used in Japan for laparoscopic surgery in 2007 was about 18 million liters, which is more than 35.384 t (Table 1). The total amount of CO_2 used during the 16-year period of 1990 through 2007 was more than 232.11 t.

Table 1. Number of patients and amount of carbon dioxide in four surgical specialties

	1990–2007		2007	
Surgical specialty	No. of patients	Amount of CO_2 (tons)	No. of patients	Amount of CO_2 (tons)
Gastroenterological Surgery	449,510	137.69	48,859	18.919
Pediatric Surgery	13,519	3.10	2,088	0.454
Gynecology	144,648	67.41	21,633	11.524
Urology	26,618	23.91	4,647	4.487
Total	**634,295**	**232.11**	**77,227**	**35.384**

Table 2. Amount of carbon dioxide per operation in our institute

Operative method	Ligation	Ultrasonic device	HALS	No. of patients	Mean operation time	Mean amount of CO_2 (L)
Hernioorhaphy	−	−	−	27	44	19
Cholecystectomy	−	−	−	21	87	83
Fundoplication	+	+	−	15	185	505
Colectomy	−	+	+	14	236	301
Gastrectomy	−	+	+	9	301	290
Esophagomyotomy	+	+	−	4	136	359
Splencetomy	−	+	−	3	168	237

Table 3. Amount of carbon dioxide per method

Method		Amount of carbon dioxides (L)
Ligation		3.8
Release of mist from the port		
	manual	2.4
	automatic system	7.7
HALS (hand-assisted laparoscopic surgery)		4.9

Discussion

The results of this study strongly suggest that the amount of CO_2 released into the atmosphere worldwide during laparoscopic surgery contributes significantly to global warming. We found that the total quantity of CO_2 used during laparoscopic surgery in Japan was 35.384 t per year. Thus, about 31.842 t of CO_2 would have been released into the air in 2007 from laparoscopic surgical procedures in Japan alone. This amount is equal to the amount of CO_2 produced by burning 13,784 L of gasoline or to the amount of gasoline required for an automobile that gets 15.1 km/L to travel 208,138.4 km, a distance is equal to 5 times the circumference of the Earth[13].

The number of laparoscopic surgical procedures increases year by year. For example, in Japan, the number of the laparoscopic surgical procedures for the gastric cancer was 2,631 in 2005, 3,657 in 2006, and 4,765 in 2007, which accounts for 24.5% of the 19,436 gastric cancer operations performed in Japan in those years[6,14]. Because laparoscopic surgery has many advantages over conventional open surgery, the percentage of laparoscopic procedures is likely to increase in future, thus further increasing the release of CO_2 into the atmosphere. In addition, the number of other minimally invasive surgical procedures that use CO_2, for example, breast surgery, thyroid surgery, and cardiac surgery, is also expected to increase. These surgical procedures, which were not included in our study, will further increase the amount of CO_2 released into the atmosphere.

This investigation focused on a single country. However, CO_2 emissions are increasing throughout the industrialized world. For example, in the United States, the number of cholecystectomies in 2000 was 324,783, which is 16 times of the number performed in Japan[15]. In addition, the number of laparoscopic bariatric surgical procedures in the USA was about 103,000 in 2003 and is increasing. Laparascopic bariatric surgery uses a large quantity of CO_2 [16].

On the basis of the results of this investigation, we cannot conclude that laparoscopic surgery has a strong effect on global warming. However, as more laparoscopic surgery is performed, the CO_2 used each year and its influence on global warming will increase. To avoid these effects, a different gas could be used during laparoscopy. A suitable laparoscopic gas has 3 characteristics : it must be noninflammable, harmless, and inexpensive. One possibility is helium[17,18]. However, helium, though nonflammable and harmless to humans, is expensive. The hanging technique is also worth considering. This technique does not require CO_2 ; instead the abdominal wall is held, and space

Table 4. Number of patients and amount of carbon dioxide in gastroenterogical surgery

Operative procedure	Amount of CO_2 / procedure	1990–2007		2007	
		No. of patients	Amount of CO_2 (tons)	No. of patients	Amount of CO_2 (tons)
Esophagus					
Fundoplication	500	1,361	1.34	170	0.167
Esophagectomy	600	4,118	4.85	733	0.864
Esophagomyotomy	360	858	0.61	141	0.100
Others	500	908	0.89	103	0.101
Stomach					
Closure for perforation	500	594	0.58	110	0.108
Gastrectomy for cancer	290	21,048	11.99	4,765	2.714
Gastrectomy for submucosal tumor	300	3,257	1.92	564	0.332
Others	400	2,829	2.22	321	0.252
Duodenum					
Closure for perforation	500	3,329	3.27	402	0.395
Small intestine and colon					
Appendectomy	150	15,233	4.49	3,385	0.997
Resection	300	50,825	29.95	10,151	5.982
Gallbladder					
Cholecystectomy	80	298,354	46.88	22,599	3.551
Liver					
Resection	500	3,497	3.43	475	0.467
Spleen					
Splenectomy	230	3,324	1.50	452	0.204
Pancreas					
Recection	500	509	0.50	100	0.098
Others	400	39,466	23.26	4,388	2.586
Total		**449,510**	**137.69**	**48,859**	**18.919**

is created with stents. However, the hanging technique does not create a large enough working space. Perhaps the best solution is for surgeons who perform laparoscopic procedures to become aware of the problem of releasing CO_2 into the atmosphere and to make an effort to use CO_2 conservatively during laparoscopic surgery.

CONCLUSION

A large amount of CO_2 is released into the atmosphere during laparoscopic surgery, and the amount is likely to increase in the future. If surgeons become aware of this problem, they can use CO_2 conservatively during laparoscopic procedures and thus reduce the contribution of laparoscopic surgery to global warming.

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Table 5. Number of patients and amount of carbon dioxide in pediatric surgery

Operative procedure	Amount of CO_2 / procedure	1990–2007		2007	
		No. of patients	Amount of CO_2 (tons)	No. of patients	Amount of CO_2 (tons)
Fundoplication	500	994	0.98	142	0.139
Pyloromyotomy	80	313	0.05	20	0.003
Appendectomy	150	3,226	0.95	595	0.175
Endorectal Pull–Through	500	379	0.37	35	0.034
Cholecystectomy	80	217	0.03	22	0.003
Splenectomy	230	347	0.16	30	0.014
Repair of inguinal hernia	20	3,669	0.14	842	0.033
Contralateral side examination of inguinal hernia	15	1,872	0.06	92	0.003
Diagnostic laparoscopy	20	449	0.02	33	0.001
Orchidopexy	40	373	0.03	44	0.003
Ovarian tumor resection	80	282	0.04	38	0.006
Others	100	1,398	0.27	195	0.038
Total		**13,519**	**3.10**	**2,088**	**0.454**

Table 6. Number of patients and amount of carbon dioxide in gynecology

Operative procedure	Amount of CO_2 / procedure	1990–2007		2007	
		No. of patients	Amount of CO_2 (tons)	No. of patients	Amount of CO_2 (tons)
Endometriosis	200	29,801	11.71	4,794	1.883
Oophorectomy	150	47,580	14.02	6,680	1.968
Ectopic pregnancy	150	13,007	3.83	1,689	0.498
Hysterectomy	500	28,972	28.45	6,069	5.961
Diagnostic laparoscopy	50	11,210	1.10	408	0.040
others	300	14,078	8.30	1,993	1.174
Total		**144,648**	**67.41**	**21,633**	**11.524**

Table 7. Number of patients and amount of carbon dioxide in Urology

Operative procedure	Amount of CO_2 / procedure	1990–2007		2007	
		No. of patients	Amount of CO_2 (tons)	No. of patients	Amount of CO_2 (tons)
Adrenalectomy	400	6,362	5.00	785	0.617
Nephrectomy	500	13,875	13.63	2,900	2.848
Orchiectomy	100	863	0.17	43	0.008
Varicocele ligation	60	1,225	0.14	47	0.006
Prostatectomy	600	3,856	4.54	770	0.908
others	500	437	0.43	102	0.100
Total		**26,618**	**23.91**	**4,647**	**4.487**

for making data from their operation.

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