Biliary ICG Concentrations as an Indicatr of the Effect of Biliary Decompressions : Peak and two—hour ICG Concentrations

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SUMMARY : To quantitate the effects of biliary decompression on hepatic func-
tional reserve prior to a definitive operation in patients with obstructive jaundice,
indocyanine green (ICG) concentration in the bile was measured before and at 15
minute intervals for six hours following its administration. The maximal excretion
rate of ICG in the bile as a function of time (ICG B_{max}) was calculated by the follow-
ing equation :

$$ICG\ B_{max} = \log_e \left\{ \frac{\log_e(10 \times \text{peak concentration})}{\text{peak concentration time}} \right\}$$

Determination of ICG B_{max} has a shortcoming in that it requires prolonged restriction
of the patients. Therefore, for the purpose of simplification, the natural logarithm of
the ICG concentration two hours after ICG administration (ICG B_{2hr}) was obtained :

$$ICG\ B_{2hr} = \log_e (\text{biliary ICG concentration at two hours})$$

There was a significant correlation between ICG B_{max} and ICG B_{2hr}· with a correlation
coefficient of 0.865 as determined in 131 subjects.

ICG B_{max} is a reliable indicator in the assessment of hepatic functional reserve in
jaundiced patients after biliary decompression and prior to further surgical interven-
tions. ICG B_{2hr} assessment is a simplified method of ICG B_{max} assessment. ICG B_{2hr}
values of less than 0.5 are considered to be contraindication for surgery, with a high
probability of prolonged jaundice and poor prognosis. Values of more than 0.5 indi-
cate the advisability of surgery, while those between −0.5 and 0.5 also indicate this
if there is a trend to improvement.

INTRODUCTION

In surgical treatment of obstructive jaundice,
a two-phase operation (biliary decompression
for improvement of the jaundice and a subsequent
radical operation) has been widely used. However,
there are some cases in which jaundice is not
improved by biliary decompression (prolonged
jaundice cases) ; there are also such cases which
show complications after the radical operation.
Therefore, it seems to be indispensable to carry
out evaluation of the effect of decompression
immediately after such therapy as well as to
develop an index for diagnostic assessment.
Until now, however, no technique for evaluating
the effect of biliary decompression and no diag-
nostic index have been established. When the
authors carried out an indocyanine green (ICG)
tolerance test in patients in whom a T-tube
had been inserted after surgical treatment of
choledocholithiasis, ICG became detectable in
the bile about 15 minutes after ICG loading and
the ICG level in the bile reached a peak about

two hours later (Figure 1). When the ICG tolerance test was carried out in patients immediately after biliary decompression, the interval between ICG loading and the first detection of ICG in the bile was long and the ICG level in the bile was low. However, with an increase in the effect of biliary decompression, the interval became shorter and the ICG level in the bile increased. The authors converted the biliary ICG levels into a mathematical expression and termed the process the ICG B_{max} technique. In previous reports, the authors indicated that this ICG B_{max} is useful in the evaluation of the effect of biliary decompression as well as in the prognostic assessment in cases of prolonged jaundice.[1,2] In this paper, the authors report on the ICG B_{max} technique as well as on its simplified from (ICG B_{2hr} 2-hour technique).
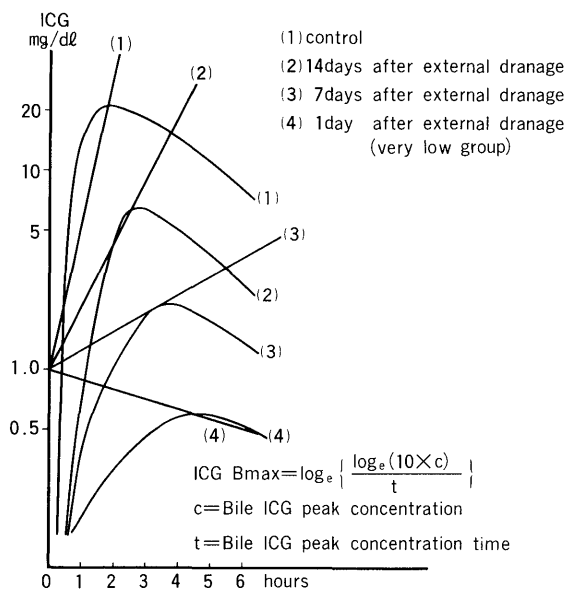
the bile was long. With an increase in the effect of biliary decompression, the ICG level increased and the interval became shorter. To express such phenomena by an equation, the peak ICG concentration was divided by the peak concentration time as shown in Figure 2. In this way, an equation consisting of the ratio of concentration to time was obtained. Furthermore, ICG concentrations were plotted on semilogarithmic graph papers. This method allows graphic presentation of both low-ICG-level cases and high-ICG-level cases on the same graph. ICG was loaded in quantities of 0.5 mg/kg. After ICG loading, the ICG levels in the bile were measured for six hours in order to obtain the peak concentration.

$$\text{ICG } B_{max}(1) = \frac{\log_e c}{t}$$
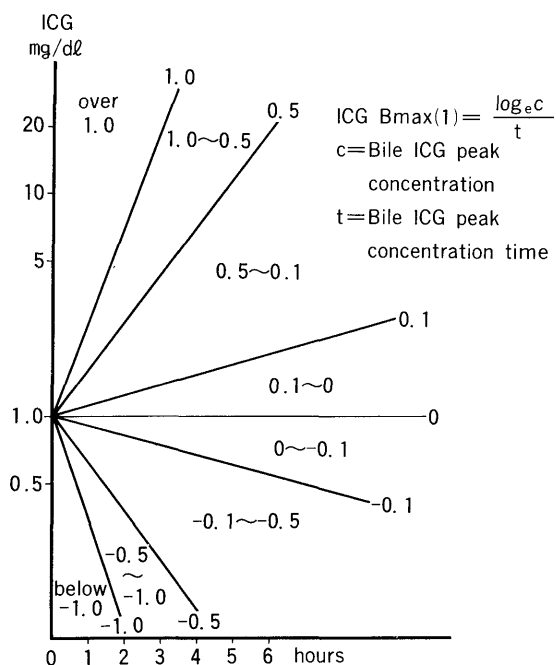
(c=peak concentration, t=time of peak concentration)

Figure 1 : Time course of ICG levels bile

Figure 2 : Calculation and graphic presentation of ICG Bmax(1)

METHOD

1. Calculation of ICG B_{max}

When the ICG tolerance test was carried out in cases of obstuctive jaundice after PTCD, the ICG level in the bile immediately after biliary decompression was low and the interval between ICG loading and the first detection of ICG in

With this equation, positive values are consistent with graphic presentation, but negative values cannot be graphically presented without involving contradiction. Therefore, the peak ICG concentration was multiplied by ten so that the

ICG level of 0.1 mg/dl and the time of 0 come to the origin (Figure 3). In this way, the first equation was modified as follows :

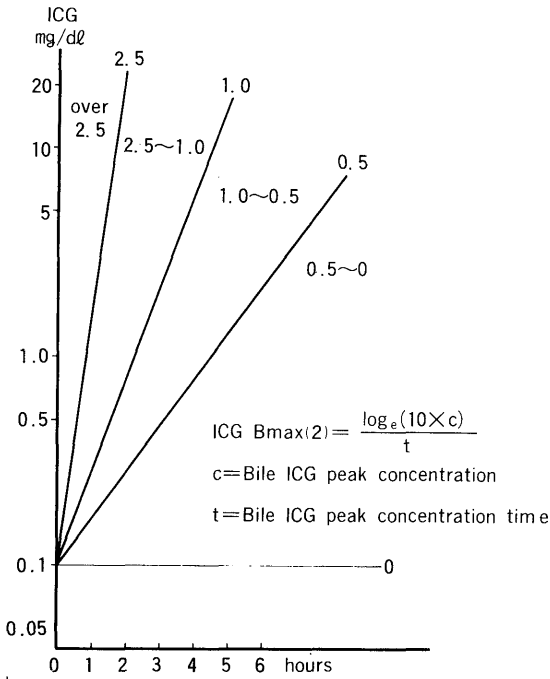$$\text{ICG } B_{max}(2) = \frac{\log_e(10 \times c)}{t}$$

Figure 3 : Calculation and graphic presentation of ICG Bmax(2)

With this equation, the peak ICG concentration was never below 0.1 mg/dl ; therefore, the gradient is positive in all cases.

To obtain simpler and more easily usable values, the second equation was transformed into an equation involving natural logarithms (Figure 4) :

$$\text{ICG } B_{max} = \log_e \left\{ \frac{\log_e(10 \times c)}{t} \right\}$$

With this equation, ICG Bmax values gradually shift from the minus side to the plus side as the peak concentration increases and the peak concentration time decreases.

2. Measurement of ICG Bmax (Table 1)

In the early morning before ICG loading, bile was collected from subjects who had fasted overnight ; than, 0.5 mg of ICG per kg was injected into the cubital vein. After ICG loading, bile was collected in light-protected test tubes
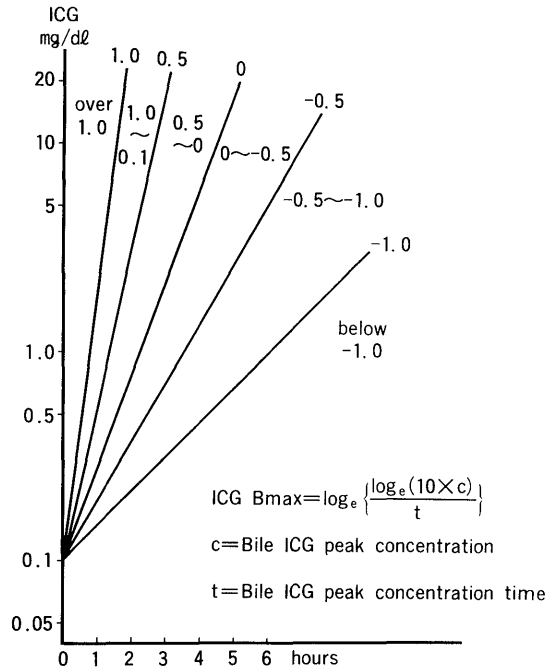

Figure 4 : Calculation and graphic presentation of ICG Bmax

Table 1 : ICG Bmax Method

Subjects : Patients with obstructive jaundice who are under biliary decompression or in whom bile can be collected with a T-tube postoperatively.

ICG loading : Intravenous injection of 0.5mg of ICG per kg in the early morning after over night festing.

Collection of bile : (1) Before ICG loading
(2) After ICG loading (for 6 hours at intervals of 15 minutes)
A light-protected test tube is used for collection.

Determination of ICG level : Collected bile is protected from light : ICG level is determined with a spectrophotometer (wv : 805nm) within 24 hours after collection.

Graphic presentation : ICG levels are plotted on semilogarithmic grahpaper as a function of time.

Calculation : From the graph. peak ICG level (C) and peak time (t) are obtained the values obtained are used for the following calculation :

$$\text{ICG Bmax} = \log e \left\{ \frac{\log e(10 \times c)}{t} \right\}$$

(c=peak ICG level. t=time of peak ICG level)

Method for fixation of ICG Bmax time

Calculation : Expressing the ICG level at a given time determined with the ICG Bmax method as a, calculation is made with the following equation.
ICG Bmax time fixation method=loge(a)
(a=ICG level at a given time)

at intervals of 15 minutes for 6 hours. ICG concentration in each bile sample(0.1 ml) was determined with a spectriphotometer at a wavelength of 805 nm. From the peak ICG concentration thus obtained and the peak concentration time, ICG B_{max} was calculated. The subjects were given breakfast after ICG loading, but lunch was not eaten until the end of the study.

3. Calculation of ICG B_{max}

With the ICG B_{max} method, the subjects must be restricted for 6 hours for collection of bile and determination of peak ICG concentration. Furthermore, this method is complicated because it necessitates a large number of samples. Figure

5 shows a way in which this ICG B_{max} method can be simplified. When we compared the ICG concentration at two hours after loading with the 6-hour peak ICG concentration, we found that the former increased in parallel with the latter. It was also found that the ICG concentration at two hours after loading increased as the peak concentration time decreased. These results indicate that 2-hour ICG concentration analysis can sufficiently reflect the variation in the two factors(ICG concentration and time). Therefore, we conducted a study to see whether or not the ICG B_{max} can be replaced with the 2-hour ICG concentration.
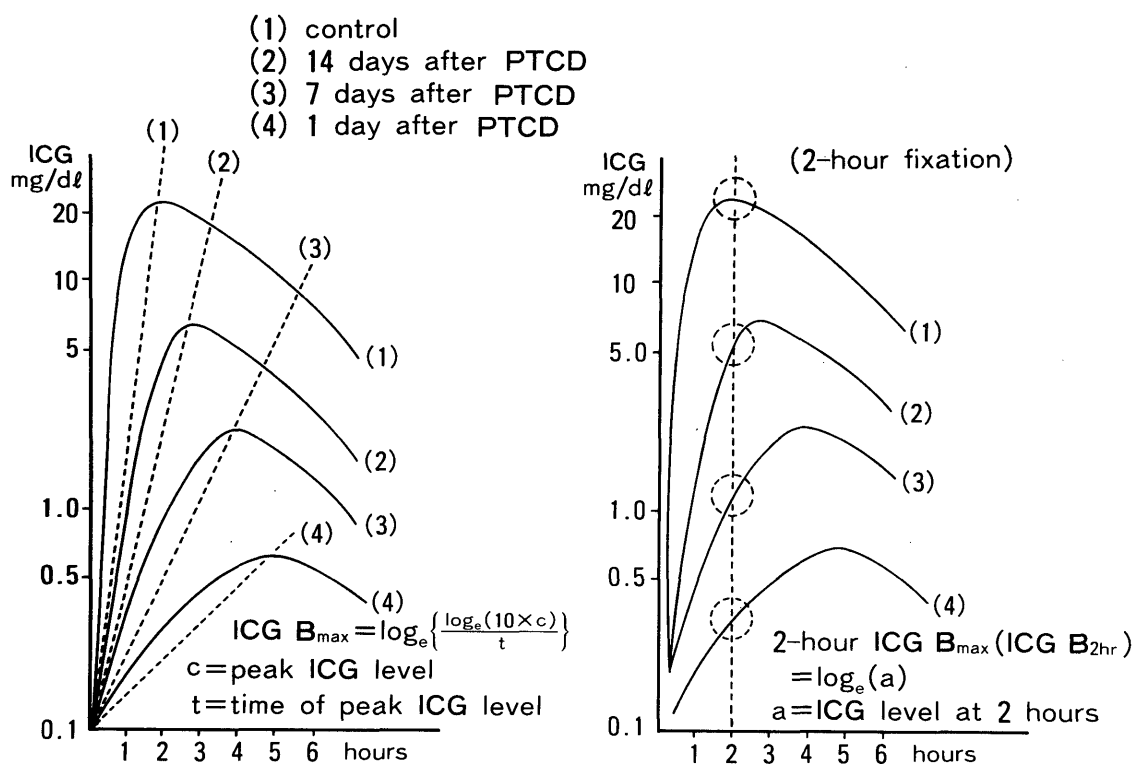
(1) control
(2) 14 days after PTCD
(3) 7 days after PTCD
(4) 1 day after PTCD

$$ICG\ B_{max} = \log_e\left\{\frac{\log_e(10 \times c)}{t}\right\}$$
c = peak ICG level
t = time of peak ICG level

2-hour ICG B_{max} (ICG B_{2hr})
$$= \log_e(a)$$
a = ICG level at 2 hours

Figure 5 : Time course of ICG levels in bile

In all of 131 patients who were subjected to B_{max} measurement in Nagasaki University School of Medicine (Second Department of Surgery) or the Kochi Prefectural Seinan Hospital, 1-hour, 2-hour, 3-hour and 4-hour ICG levels were converted to natural logarithms. Coefficients of correlation between the natural logarithm of these values and the ICG B_{max} value were calculated

(Figure 6). The coefficient of correlation was 0.692 between the 1-hour value and B_{max}, 0.865 between the 2-hour value and B_{max}, 0.832 between the 3-hour value and B_{max}, and 0.637 between the 4-hour value and B_{max}. Thus, the 1-, 2-, 3- and 4-hour values all showed statistically significant correlation with the B_{max} value. The strongest correlation was between the
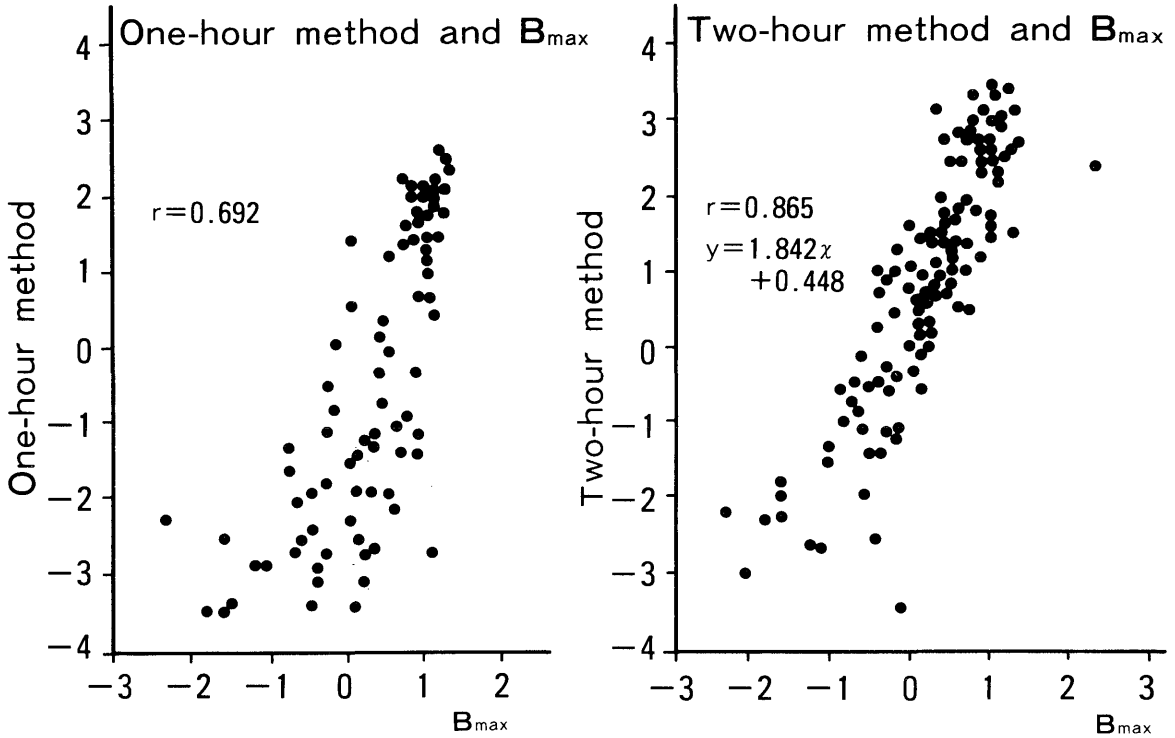
Figure 6 : Correlation of one-hour and two-hour methods with Bmax method

2-hour value and the B_{max} value. Therefore, we adopted the 2-hour method (ICG B_{2hr}) as a simplified from of the ICG B_{max} method.

ICG B_{2hr} (a simplified from of ICG B_{max}) $= \log_e$ (a)

(a = ICG concentration at two hours after ICG loading)

RESULTS

1. Normal controls

Sixteen patients showing normal values in hepatic function and other tests served as controls. All of these controls had in-dwelling choledochal T-tubes or had received PTCD 30 days or more before (Table 2). In these controls, the peak ICG concentration ranged between eight and 33 mg /dl (mean ± S. D. = 20.1 ± 8.2 mg/dl). The peak ICG concentration time ranged between 1.25 and 2.75 hours (mean ± S. D. = 1.9 ± 0.4 hours). The ICG B_{max} value was 0.5 or more in all cazes (mean ± S. D. = 1.1 ± 0.27).

In analysis of ICG B_{2hr}, the ICG concentration at 2 hours after loading ranged between 4.6 and 32.3 mg/dl (mean ± S. D. = 17.0 ± 9.4 mg/dl). These values of the 2-hour ICG concentration are very close to the 6-hour peak ICG concentration (mean : 20 mg/dl). The ICG B_{2hr} value $\log_e$(a) was 1.5 or more in all cases (mean : 2.7). The ICG B_{2hr} value of 1.5 corresponded to the ICG B_{max} value of 0.5. Therefore, the lower normal limit was set at 0.5 (ICG B_{max}) and 1.5 (ICG B_{2hr}).

2. Subjects of ICG B_{max} Analysis

The subjects of this analysis were 26 patients with obstructive jaundice who received biliary decompression at the Department of Surgery, Nagasaki University School of Medicine. Of these cases, 23 were malignant and three were benign. We carried out a total of 84 measurements of ICG B_{max} in these subjects. The subjects were divided into three groups according to the ICG B_{max} value obtained immediately after biliary decompression. We determined the relationship between ICG B_{max} and ICG B_{2hr} values in these three groups.

1. Very low ICG B_{max} group (ICG B_{max} below −0.5, ICG B_{2hr} below −0.5)

Table 2 : Control group

Case	external dranage	peak time	peak level	2-hour level	ICG B$_{2hr}$	ICG B$_{max}$
1 A	T-tube	2.0 hours	32.3 mg/dl	32.3 mg/dl	3.5	1.10
2 A	T-tube	2.75	16.9	11.0	2.4	0.62
3 B	T-tube	1.5	11.3	9.9	2.3	1.20
4 A	T-tube	1.75	11.6	5.6	1.7	1.00
5 B	Splint-tube	1.25	11.3	4.6	1.5	1.30
6 A	T-tube	1.5	20.4	14.0	2.6	1.30
7 A	T-tube	1.5	26.3	23.8	3.2	1.30
8 C	Splint-tube	2.0	29.5	29.5	3.4	1.70
9 D	PTCD	2.5	23.0	18.5	2.9	0.78
10 A	T-tube	1.75	32.8	29.9	3.4	1.20
11 B	T-tube	2.5	19.1	16.2	2.8	0.74
12 D	PTCD	1.75	13.3	11.4	2.4	1.00
13 D	PTCD	2.0	13.5	13.5	2.6	0.90
14 A	T-tube	1.5	8.0	4.7	1.6	1.10
15 A	T-tube	2.0	29.4	29.4	3.4	1.00
16 A	T-tube	2.5	27.7	17.2	2.8	0.78
Mean		1.9±0.4	20.1±8.2	17.0±9.4	2.7±0.65	1.1±0.27

A : Choledocholithiasis C : Cholecystolithiasis   Mean±S. D.
B : Intrahepatic stone   D : Bile duct carcinoma

Table 3 : ICG B$_{max}$in very low group (below−0.5) (ICG B$_{2hr}$ below−0.5)

Case	Immediately after biliary decompression				Before radical operation				Prolonged jaundice	Cholangitis	Prognosis
	T. B. mg/dl	ICG B$_{max}$	2-hour lever	ICG B$_{2hr}$	T. B. mg/dl	ICG B$_{max}$	2-hour lever	ICG B$_{2hr}$			
1 A	21.1	−1.70	0.0	−3.0	23.0	−1.9	0.07	−2.7	+	−	death
2 A	29.0	−1.2	0.07	−2.7	41.3	−2.0	0.05	−3.0	+	+	death
3 B	10.2	−0.66	0.6	−0.51	14.5	−1.8	0.1	−2.3	+	+	death
4 C	7.5	−1.7	0.15	−1.9	2.9	0.07	0.75	−0.29	+	+	complicated
5 D	9.6	−1.6	0.0	−3.0	7.9	0.14	0.89	−0.12	+	+	good
6 A	30.8	−1.6	0.15	−1.9	7.8	−0.03	1.1	0.06	+	+	complicated
7 A	26.0	−1.2	0.07	−2.7	21.3	0.16	1.3	0.29	+	+	good
8 E	27.7	−0.85	0.56	−0.58	15.6	−0.69	0.46	−0.78	+	−	good
9 A	17.6	−0.8	0.57	−0.56	10.5	−0.61	0.85	−0.16	−	−	complicated
Mean	19.9±9.1	−1.3±0.41	0.24±0.26	−1.9±1.0	16.1±11.4	−0.74±0.93	0.62±0.47	−1.0±1.2	8/9 89%	5/ 56%	

A : Bile duct carcinoma   D : Choledocholithiasis   Mean±S. D.
B : Carcinoma of the gallbladder   E : Ampullary carcinoma
C : Intrahepatic stone

Note : For the sake of convenience, the 2-hour level O was regarded as the ICG B$_{2hr}$ value -3.0.

The nine subjects in whom ICG B$_{max}$ was below −0.5 were allocated to the very low group (Table 3). In these nine patients, the total bilirubin level ranged between 7.5 and 30.8 mg/dl (mean : 19.9 mg/dl), indicating jaundice of severe degree. In analysis of ICG B$_{max}$' the peak ICG concentration ranged between 0.305 and 1.74 mg/dl (mean : 0.689 mg/dl). The 2-hour ICG concentration was also markedly low(mean : 0.24 mg/dl). Thus, the values in this group were very low compared to the controls. The mean ICG B$_{max}$ was −1.3, and ICG B$_{2hr}$ was below

−0.5 in all cases (mean : −1.9).Thus, the ICG B2hr values agreed well with the ICG Bmax values. Eight of the subjects showed prolonged jaundice. Three patients from this group, who had not shown any improvement in ICG Bmax or ICG B2hr before radical surgery, had a poor prognosis and died after the operation. Of the remaining six patients who had shown some improvement in ICG Bmax or ICG B2hr before the radical operation, none died after the operation, although postoperative complications occurred in three. Thus, both the ICG Bmax and the ICG B2hr methods were found to be useful as a prognostic index in severe cases of prolonged jaundice.

3. Moderately low ICG Bmax group (ICG Bmax between −0.5 and 0 ; ICG B2hr between −0.5 and 0.5)

The seven subjects in whom the ICG B

between −0.5 and 0 were allocated to the moderately low group (Table 4). In this group, ICG B2hr ranged between −0.5 and 0.5. In these seven patients, the mean total bilirubin was 15.5 mg/dl, indicating jaundice of severe degree. In analysis of ICG Bmax, the peak ICG concentration ranged between 1.19 and 5.35 mg/dl (mean : 2.90 mg/dl). The 2-hour ICG concentration averaged 0.93 mg/dl. The mean ICG Bmax was −0.33 and the mean ICG B2hr was −0.53. Four of the seven patients showed prolonged jaundice. In three of the seven patients, the 2-hour value was not within the preset range of values for this group. Compared to the very low and high value groups, the moderately low value group is an ambiguous one. In analysis of ICG B2hr, this group tended to merge into one or the other of the remaining two groups.

Table 4 : ICG Bmax in the moderately low group
(between−0.5 and 0)(ICG B2hr between−0.5 and 0.5)

Case	Immediately after biliary decompression				Before radical operation				Prolonged jaundice	Cholangitis	Prognosis
	T. B. mg/dl	ICG Bmax	2-hour level	ICG B2hr	T. B. mg/dl	ICG Bmax	2-hour level	ICG B2hr			
1 A	21.5	−0.19	0.65	−0.43	5.9	0.85	6.0	1.8	+	−	complicated
2 B	9.7	−0.38	0.23	−1.5	2.1	0.31	4.0	1.4	−	−	good
3 A	25.7	−0.46	0.08	−2.5	5.3	−0.12	0.3	−1.2	−	−	good
4 C	7.0	−0.41	2.8	1.0	1.3	0.15	3.6	1.3	−	−	good
5 B	20.0	−0.12	1.2	0.18	11.1	0.16	0.56	−0.58	+	+	good
6 C	11.5	−0.40	0.75	−0.29	8.0	0.52	5.7	1.7	+	−	death
7 A	13.5	−0.34	0.82	−0.20	3.8	0.78	18.5	2.9	+	−	good
Mean	15.5±6.9	−0.33±0.13	0.93±0.90	−0.53±1.1	5.3±3.4	0.38±0.35	5.5±6.1	1.0±1.4	4/7 57%	1/7 14%	

A : Bile duct carcinoma

B : Carcinoma of the gallbladder

C : Carcinoma of the pancreas

4. High ICG Bmax group (ICG Bmax over 0, ICG B2hr over 0.5)

The 10 subjects in whom Bmax was over 0 were allocated to the high value group (Table 5). In this group, the ICG B2hr was over 0.5. The total bilirubin level averaged 15.6 mg/dl, indicating jaundice of severe degree. In analysis of ICG Bmax, the peak ICG concentration averaged 5.12 mg/dl. The 2-hour ICG concentration averaged 2.5 mg/dl. The mean ICG Bmax was 0.33, and the mean ICG B2hr was 0.80. In this group, the total bilirubin level after biliary decompression was

not different from that in the very low and moderately low groups. However, the effect of biliary decompression was greater in this group than in the other two groups. Prolonged jaundice was observed in only one of the 10 subjects, and prognosis was good in this group. Of the three subjects who had a poor prognosis, two showed ICG B2hr values which fell under the category of the moderately low group. As a prognostic index, ICG B2hr proved to be more useful than ICG Bmax.

5. All groups

Table 6 shows the mean values for each group.

Table 5 : ICG B_{max} in the high group (over 0)(ICG B_{2hr} over 0.5)

Case	Immediately after biliary decompression				Before radial operation				Prolonged jaundice	Cholangitis	Prognosis
	T. B. mg/dl	ICG B_{max}	2-hour level	B_{2hr}	T. B. mg/dl	ICG B_{max}	2-hour level	B_{2hr}			
1 A	12.8	0.34	4.2	1.4	2.2				−	−	good
2 B	14.6	0.42	4.0	1.4	2.1	1.1	19.4	3.0	−	−	good
3 C	8.1	0.30	3.1	1.1	3.5	0.55	11.5	2.4	−	−	good
4 D	8.2	0.26	1.9	0.63	1.9				−	−	good
5 D	19.9	0.72	3.0	1.1	3.5	0.46	4.7	1.5	−	−	good
6 C	12.2	0.34	3.6	1.3	2.5	1.0	11.4	2.4	−	−	good
7 E	10.7	0.15	1.2	0.18	4.1	0.28	2.4	0.8	−	−	good
8 C	23.5	0.23	0.91	−0.09	3.9	0.37	2.6	0.9	−	−	death
9 C	20.3	0.13	1.3	0.26	6.4	0.21	3.7	1.3	−	−	complicated
10 F	25.6	0.42	2.1	0.73	15.3	−0.52	0.64	−0.45	+	−	deathh
Mean	15.6±6.3	0.33±0.17	2.5±1.2	0.80±0.54	4.5±4.0	0.44±0.51	7.9±6.3	1.7±0.82	1/10 10%	1/10 10%	

A : Hepatoma   D : Bile duct carcinoma   Mean±S. D.
B : Chronic pancreatitis   E : Carcinoma of the gallbladder
C : Carcinoma of the pancreas   F : Ampulary carcinoma

Table 6 : Mean values for each group

Group	Immediately after biliary decompression				Before radical operation				Prolonged Jaundice	Cholangitis	Poor prognosis
	T. B. mg/dl	ICG B_{max}	2-hour level	ICG B_{2hr}	T. B. mg/dl	ICG B_{max}	2-hour level	ICG B_{2hr}			
High group	15.6	0.33	2.5	0.8	4.5	0.44	7.9	1.7	10%	10%	30%
Moderately low group	15.5	−0.33	0.93	−0.53	5.3	0.38	5.5	1.0	57%	14%	29%
Very low group	19.9	−1.30	0.24	−1.9	16.1	−0.74	0.62	−1.0	56%	56%	67%
Control group					1.1	17.0	2.7				

In all groups, the degree of improvement was greater before the radical operation than immediately after biliary decompression. Improvement was slower in the high level group than in the other two groups. In the high level group, the total bilirubin level was 16.1 mg/dl, indicating jaundice of severe degree. In this group, prolonged jaundice, cholangitis and poor prognosis were observed in 89%, 56% and 67% of the subjects, respectively. As a prognostic index, ICG B_{2hr} proved to be more useful. Determination of ICG B_{max} immediately after biliary decompression allows a judgment as to the presence or absence of prolonged jaundice and as to the prognosis. FurtNermore, weekly measurement of ICG B_{max} enables us to decide on the time of the operation based on the improvement in the ICG B_{max} value.

CASE RRESENTATION

The case of a 30-year-old male is reported here. At the age of 25 years, this patient received choledochotomy and cholecystomia externa for treatment of choledocholithiasis and gallbladder calculus. At the age of 29 years (one year ago), he began to show pyrexia, jaundice, leukocytosis and epigastralgia once a month : he was diagnosed as having cholangitis and was repeatedly admitted to and discharged from the hospital. Because the above-mentioned symptoms lasted for eight days and a state of shock was observed, he was admitted to the Second Department of Surgery, Nagasaki University Hospital. Upon admission, the total bilirubin was 11.2 mg/dl.

A 30-year-old male with choledocholithiasis

-PTCD
-choledochojejunostomy
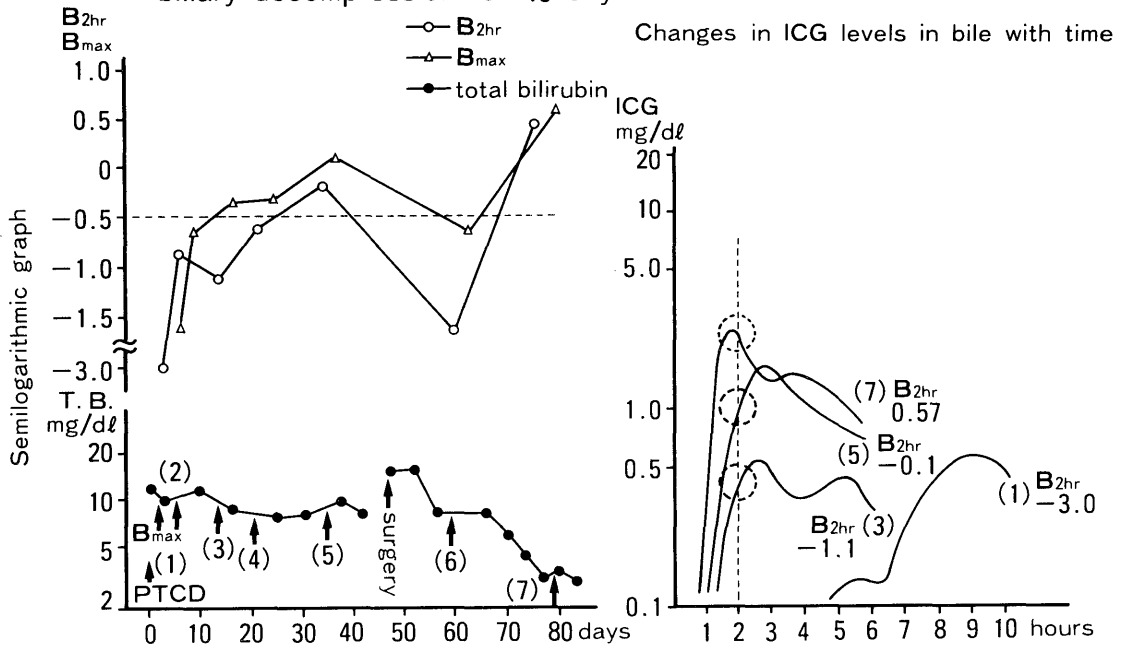-jaundice lasting for one year
-biliary decompression for 46 days

Figure 7 : Case report

After he was diagnosed as having obstrutive suppurative cholangitis, he was subjected to PTCD. During this treatment, bile resembling white pus flowed out, indicating that he had a calculus incarcerated in the choledochus. The mean volume of the bile outflow was 500 ml. Total bilirubin was as high as 9.5 mg/dl when measured one month later, indicating prolonged jaundice. ICGB$_{max}$ was measured once a week (seven measurements in total). In analysis of ICG B$_{2hr}$ the value remained at a very high level in the early days of disease (-3, -0.8, -1.1 and -0.6, in order of time), but it had declined to the moderately low level of -0.1 on day 32 of the disease. When this improvement was noted, choledochojejunnostomy was carried out. The postoperative course was favorable, with no complications. As shown in Figure 7, ICG B$_{max}$ and ICG B$_{2hr}$ followed almost the same time course.

DISCUSSION

Recent progress in diagnostic imaging techniques has made it possible for us to diagnose obstructive jaundice rapidly and accurately. Under an ultrasonographic guidance, PTCD is now a safer operation than ever. For this reason, obrtructive jaundice is now commonly treated with a two-phase operation in which radical surgery is carried out after biliary decompression. However, because of the absence of an index for assessment of the effect of biliary decompression, 30 or more days are uniformly taken as the period of biliary decompression before radical surgery. Thus, the radical operation tends to be delayed. The duration of biliary decompression was similar in our cases ; it was 34.8 days on average in the high ICG B$_{max}$ group showing a good effect of biliary decompression, and 39.6 days on average in the very low ICG B$_{max}$ group

showing a poor effect of biliary decompression. Thus, there was a difference of only five days between these two groups. We think the duration of biliary decompression can be shortened, at least in the high ICG B_{max} group.

The decision to carry out a radical operation is often made when the total bilirubin level falls below 5 mg/dl. In prolonged jaundice cases, such a decision is made when the total bilirubin does not drop below 5 mg/dl within 30 days after biliary decompression or when value b of the b iliary decompression rate[3] exceeds −0.05. This indicates that the duration of biliary decompression is long if the total bilirubin level is used as an index. In prolonged jaundice cases, treatment is often carried out too late because the decision about treatment cannot be made before the end of the 30-day biliary decompression period.

Possible factors responsible for prolonged jaundice are : (1) a long interval from the onset of jaundice to the enforcement of biliary decompression and (2) the presence of an infection such as cholangitis. The use of ICG B_{max} allows a diagnosis of prolonged jaundice immediately after biliary decompression ; therefore, necessary treatment may be started immediately after biliary decompressivn with the use of this index. If infection is found, thorough countermeasures against infection as well as administration of bile acids, insulin, glucagon, etc. are carried out. As an interim report, some of our cases have shown improvement after such measures, although evaluation has not yet been completed in tese cases.

In obstructive jaundice cases, the hepatocellular mechanism of secreting bile into the bile capillaries is disturbed. Furthermore, qualitative alteration in mitochondria has been found in such cases.[4] Since biliary secretion is energy dependent, an alteration in mitochondria can disturb it. ICG is secreted into the bile capillaries by the same mechanism as that of bilirubin secretion, thereby competing with bilirubin secretion.[5] For this reason, time course observation of the ICG secretion into the bile after biliary decompression means observation of the course of recovery of the disturbed bile secretion mechanism.

With increasing effect of biliary decompression,

the ICG B_{max} value improves to a large degree. This index is useful not only as a prognostic index in the early phase of biliary decompression but as an index of bile secretory capacity at a given time.

ICG B_{2hr} is a simplified from of ICG B_{max}. With the ICG B_{2hr} method, the ICG level in the bile has to be determined only at 2 hours after ICG loading. ICG B_{2hr} shows a significant correlation with ICG B_{max} ($r=0.865$). ICG B_{2hr} proved to be more useful than ICG B_{max} as a prognostic index.

CONCLUSION

(1) ICG B_{max} measurements reflected well the degree of hepatic dysfunction in cases of obstuctive jaundice. The use of this index allows a diagnostic judgment immediately after biliary decompression. By means of time course measurement of this index, we can pass a judgment about the time of surgery.

(2) ICG B_{max} values below −0.5 mean that surgery is contraindicated ; positive ICG B_{max} values mean that surgery is indicated ; and values between −0.5 and 0 mean that the patient shows a trend of improvement and can be surgically treated.

(3) ICG B_{2hr} is a simplified from of ICG B_{max}. ICG B_{2hr} values below −0.5 mean that the patient has prolonged jaundice and that surgery is contraindicated because of the possibility of poor prognosis ; values over 0.5 mean that surgery is indicated ; and values between −0.5 and 0 indicate that the patient shows a trend of improvement and can be surgically treated.

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