PAPERS AND ORIGINALS

The Brighton resuscitation ambulances: a continuing experiment in prehospital care by ambulance staff

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Summary

Two ambulances from the existing fleet in Brighton and one in Hove are equipped with portable defibrillator-oscilloscope units. Selected attendants have been trained not only to defibrillate patients but also to perform endotracheal intubation and administer intravenous atropine and lignocaine for carefully defined indications. In the two years up to December 1975 the ambulances responded to 2253 calls which were considered possible emergencies. Retrospective analysis showed that half of these had been for patients with myocardial infarction, coronary insufficiency, or angina. The ambulances took a median time of five minutes to reach a patient. Attempts at resuscitation were made in 207 patients with circulatory arrest, of whom 160 had ventricular fibrillation. Co-ordinated rhythm was restored at least transiently in 66 patients, and 27 of them survived to leave hospital. Sixteen of the survivors had been in ventricular fibrillation before the arrival of the ambulance. The delay

before admission to hospital was reduced: over 50% of patients carried in the ambulances were admitted within two hours of the onset of major symptoms. No extra ambulance staff have been employed for the scheme. The increased load on hospital services has been limited by encouraging a rational admission policy and also by early discharge.

Introduction

The concept of mobile coronary care was introduced by Pantridge and his colleagues 10 years ago.¹ The benefits of starting emergency treatment with the least possible delay and before patients have been moved to hospital have been amply demonstrated.¹⁻³ Similar schemes have proved successful in many cities overseas, particularly in the United States.⁴⁻⁸ Relatively few units operate in Britain, but a recent report by a joint working party of the Royal College of Physicians of London and the British Cardiac Society recommended that mobile coronary care should be further developed to help counter the high death rate in the first three hours after infarction.⁹

Few authorities deny the value of a service of this type, but some question its cost-effectiveness. Coronary ambulances are rarely as expensive as their critics seem to believe, however, for various methods have been found of adapting existing services to provide the necessary facilities. In Brighton we decided to train a group of ambulancemen in many of the clinical aspects of coronary disease so that they could, with confidence, provide general care and treat ventricular fibrillation without direct supervision from doctors or nurses. Our early experience, reported in 1973,¹⁰ encouraged us to continue and to develop the experiment. We considered that results could be improved by increasing from two to three the number of special ambulances available at any time, by using more compact and portable equipment, and by further extending the training and expertise of the attendants. We planned that they should become skilled technicians in resuscitation, able not only to defibrillate patients but also to stabilise the heart rhythm with selected intravenous drugs, to intubate patients with respiratory arrest, and to set up

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infusions for hypovolaemic shock. Unfortunately the extension of our training programme was interrupted by problems concerned with reorganisation of the National Health Service and subsequently by financial problems; it has only recently been resumed. Nevertheless, we report here our results from January 1974 to December 1975, for these lend further support to the concept that ambulancemen can play a valuable and life-saving role in prehospital care.

Vehicles and equipment

Three ambulances are now in use, two operating from Brighton and one from Hove. These stations are widely separated and well placed to provide between them rapid access to most parts of the Brighton Health District.

Before 1974 the two ambulances based in Brighton were slightly modified vehicles of the existing fleet, each carrying a non-portable defibrillator and separate monitoring oscilloscope. This inflexible arrangement had considerable disadvantages. When portable equipment became readily available we bought combined defibrillator-oscilloscope units (Cardio-Aid, Simonson and Weel DMS 200). All new stretcher-bearing vehicles were slightly modified to provide a convenient wooden base for the charging bracket of the defibrillator. Thus we no longer have vehicles permanently designated as coronary ambulances; any vehicle can be adapted within a few minutes to provide this facility by simple transfer and anchoring of a single fitment. In practice the equipment is switched at intervals of days or weeks, depending upon operational requirements. Although no extra ambulances were provided for resuscitation work, designated vehicles are kept back from routine work whenever possible.

The whole defibrillator-oscilloscope unit is readily portable and will slide out of its charging bracket. It is always taken to the patient before he is moved and a baseline rhythm electrocardiogram (ECG) is recorded. In acute emergencies the ECG can be detected through the defibrillator electrodes placed on the chest; a life-threatening arrhythmia can therefore be identified and treated by a shock with a minimum of delay and manipulation. The large memory-oscilloscope of the Cardio-Aid can be seen clearly within the ambulance and is used for routine monitoring of patients during transit.

A small National Panasonic tape-recorder (RQ212DS) is fitted within the lid of each Cardio-Aid for storing the patient's ECG as a frequency-modulated tone on a tape-cassette; this is analysed subsequently within the coronary care unit. A single channel Cardiostat-T electrocardiograph (Siemens) is attached to the charging bracket of the Cardio-Aid; a conventional ECG can therefore be recorded within the ambulance for immediate diagnostic purposes.

Training the ambulancemen

The training of the volunteer ambulancemen has been described briefly¹⁰ but has since been extended. The first stage comprises a six-month course of weekly lectures. These cover some anatomy and physiology of the cardiovascular system, a detailed consideration of the natural history of coronary disease and its complications, elementary pharmacology of the drugs used to treat coronary disease, electrocardiography to a standard which demands recognition of all common arrhythmias, and practical instruction in resuscitation procedures. The lectures are shared with nurses on a joint course in intensive and coronary care. Ambulancemen who pass a searching examination are then permitted to act as attendants on the resuscitation ambulances and to defibrillate patients if the need arises; the minority who fail are given the chance to take the examination again six months later.

After the successful ambulancemen have had about six months operational experience, they are encouraged to attempt a more difficult test, which requires a standard of arrhythmia recognition at least comparable to that of well-trained medical registrars and to have a detailed knowledge of the clinical pharmacology of atropine and lignocaine. When successful, they may give these drugs intravenously at their own discretion but for indications which are very carefully defined. The time of the start of any injection is recorded on the cassette tape.

After further instruction and assessment a few of the men have been permitted to treat patients with respiratory arrest by intubation and to set up infusions of dextran 70 for patients with hypovolaemic shock.

During the time covered by this report, our training programme remained incomplete for reasons mentioned above. Ideally we require 10 operational men for every special ambulance. Twenty-seven men had been passed as proficient for defibrillation, but eight of these were controllers and no longer serving as attendants. The numbers trained for drug administration, intubation, and infusion techniques were respectively 19, seven, and two. These skills originally attracted an increase in salary of 10% for proficiency in general care and defibrillation, and an additional 5% when the other stages were complete so that the men could be regarded as fully trained "resuscitation technicians." After a fresh pay agreement dating from 1974 the extra payments were "frozen" and now constitute a much lower percentage of present day salaries. No additional staff have been employed for the scheme so the small salary increment is the only running charge to be met from NHS resources.

Deployment of ambulances and admission policy

Ambulance control are responsible for deciding whether to send a resuscitation ambulance or a conventional one. The only criterion is one of possible need. Thus if a general practitioner requests transfer of a patient with a possible coronary attack the special vehicle will generally be sent as a matter of routine. But a resuscitation vehicle is also sent for any call from any source if the controller considers that the patient might be suffering from cardiac symptoms or has any life-threatening condition. Thus patients with chest pain, severe breathlessness, or palpitations; all those who have collapsed or have been seen to have a convulsion (unless they are known epileptics); and patients who are unconscious or severely injured will travel in the specially equipped vehicles. The two ambulance stations liaise closely, and only rarely is an appropriate call received when no special ambulance is readily available.

Family doctors are encouraged not to visit a patient they suspect of having a coronary attack before calling an ambulance. Usually, the ambulance reaches the patient before or very soon after the doctor; only a few journeys are wasted because hospital admission is subsequently deemed unnecessary, and much valuable time is saved. If the doctor cannot make an early visit the ambulance will take the patient to hospital.

We have managed to maintain an open-house policy whereby any patient thought by the general practitioner (on the basis of a visit or a message) to require urgent inpatient treatment is taken to the main hospital without his having any obligation to make prior arrangements for a bed. We have asked that this facility be restricted to younger patients, but in practice the matter is left to the discretion of the practitioner.

The ambulance and hospital services also liaise closely but the method for notifying the arrival of new patients depends on the apparent urgency of the case. If a patient in the ambulance has required major resuscitation ambulance control contacts the accident and emergency department by a special telephone line which bypasses the hospital switchboard. This enables the full resuscitation team to meet the ambulance as it arrives. If the ambulance attendant believes that a patient not requiring resuscitation is nevertheless suffering from a coronary attack control will alert the coronary care unit through the conventional telephone link; a member of the cardiac firm will meet the vehicle if circumstances permit, to facilitate quick admission to the unit. The early warning also provides time for any rearrangement of beds that might be necessary. Undiagnosed patients not requiring resuscitation are brought to the emergency department in the ordinary way for diagnosis by a casualty officer without prior notification.

Findings during two years

NUMBERS OF PATIENTS AND DIAGNOSES

During 1974 and 1975 the ambulances responded to 2253 calls which were considered to be possible emergencies by ambulance control. Of these 1046 patients were carried as a result of instructions from general practitioners, 1153 after requests from the general public (most by 999 emergency calls), and the remaining 54 were transferred from one hospital to another or moved after consultants' domiciliary visits. Retrospective analysis of the diagnoses showed that 665 (30%) were suffering from myocardial infarction, 460 (20%) from coronary insufficiency or angina, and 1128 (50%) from other diagnoses, which included some primary arrhythmias and sudden deaths not known to be due to coronary disease but were mostly non-cardiac problems.

TIME ANALYSES

Time analyses were available for all cases in which the resuscitation ambulances were used, though data are necessarily incomplete. For example, the time of onset of major symptoms cannot always be defined.

The median time from onset of symptoms to the ambulance being called was 65 minutes (131 minutes for those patients who called a general practitioner first, and 24 minutes for those who did not). The median time for the ambulance to reach the patient after the call was five minutes. On average it took 25 minutes to move the patient to hospital. Six per cent of patients reached hospital within 30 minutes, 30% within an hour, and 54% within two hours of the onset of major symptoms.

AMBULANCEMEN'S DIAGNOSIS OF HEART RHYTHM

Heart rhythms were analysed by a registrar or experienced senior house officer from tape recordings of the electrocardiogram in 2180 of the patients carried in the ambulances. There was 94% agreement between ambulance men and registrars in interpreting 3158 recorded rhythms (90% if sinus rhythm is excluded). Forty-five rhythm abnormalities present on tapes were not seen by attendants. Conversely, they reported 99 abnormalities from oscilloscope readings that were not identified on the tapes, but these were usually associated with technical recording failures and so did not necessarily indicate errors. Cases in which the tape had not been recorded included six reported as having ventricular fibrillation; in all cases the attendants had failed to switch on the recorder in their anxiety to defibrillate patients without delay. In only 68 cases (2.2%) did we think there were definite differences of interpretation.

DRUG ADMINISTRATION BY AMBULANCEMEN

Eighty-five patients were given intravenous lignocaine and 127 were given atropine by the ambulance men. More would have been given drugs if all ambulance men had been trained in drug administration. The indications for drugs were exactly as defined in all but four cases. On three occasions atrial fibrillation or supraventricular tachycardia was mistaken for ventricular tachycardia and lignocaine was administered. In the one important error, which was fortunately without effect, lignocaine was given to a patient with a slow idioventricular rhythm. For one patient treated with atropine no tape or ECG tracing was available for subsequent checking.

In terms of ECG abnormality 111 of the 212 patients were considered to have responded wholly or partly to their drugs. Seventy-one patients with various types of bradycardia did not respond satisfactorily to atropine, but many of these had been treated for circulatory arrest. Lignocaine seemed effective in controlling ventricular extrasystoles in 35 out of 49 patients but was ineffective in eight out of 10 patients to whom it was given for ventricular tachycardia alone.

Etonox (50% nitrous oxide, 50% oxygen) was used for pain relief, but we did not formally assess its value.

TREATMENT OF CARDIAC ARREST

Attempts at resuscitation were made on 207 patients with circulatory arrest. Of these, 47 had asystole when first seen and none survived. The other 160 had ventricular fibrillation, and all but 13 were found with the arrhythmia. Co-ordinated rhythm was restored at least transiently in 66 patients. Twenty-seven survived to leave hospital; 16 of these patients had been in ventricular fibrillation when first seen by the ambulance crew.

SUBJECTIVE EVALUATION OF THE AMBULANCE SERVICE

We wrote to all general practitioners in the area served by the resuscitation ambulances enclosing a four-page questionnaire to be completed anonymously so that criticism could be made freely. Replies were received from 129 (92%) practitioners. The most important question concerned the overall value of the scheme: 126 approved of it, two did not know, and only one opposed it. Few adverse criticisms were recorded, and many added unsolicited praise for the expertise of the ambulance men. Intubation attracted most

wariness, many doctors emphasising the need for careful training under expert supervision.

We also gave a simple questionnaire to 100 unselected patients who had travelled in the ambulance and survived episodes of myocardial ischaemia. Eighty-seven of them were aware that the vehicle was modified to deal with cardiac and other emergencies; all but two of these patients found the equipment and the special attention reassuring and denied that they increased anxiety.

Discussion

The results of the Brighton experiment confirm that ambulance men working without direct supervision can provide effective prehospital care for patients suffering from severe complications of coronary artery disease. Similar experiences have been reported from Melbourne,¹¹ and from a smaller-scale study in Dublin.¹²

We chose not to use radiotelemetry for transmitting ECGs into the coronary care unit, which would permit consultation on emergency treatment, though this system can work very successfully for ambulance men¹³ or for groups who are not primarily medically trained, such as the fire-department units of Portland, Oregon.⁵ In Brighton we do not have a medical officer in the coronary care unit throughout 24 hours, and any attempt at consultation might cause serious delay. We believe that a comprehensive training programme can provide both the skills and the confidence for paramedical staff to handle emergencies unaided and in the shortest possible time. Our system of recording ECGs for retrospective analysis does permit careful monitoring of ambulance men's performance; although this has been routine during the experimental phase of our scheme, analysis of tapes in a routine service could reasonably be restricted to cases in which a therapeutic intervention had been made.

No single coronary or resuscitation ambulance system can be ideal for all circumstances. Ambulances manned by doctors^{1 14 15} should obviously have most to offer and are feasible in some areas, but considerations of cost and manpower preclude their general use. Training paramedical personnel to undertake limited highly skilled tasks is in line with modern concepts for the delivery of cost-effective health care, but the scope and depth of such training must depend on local needs and the opportunities for instruction and supervision. Up to now the emphasis in Brighton has been on coronary care, but when our programme is complete other aspects of resuscitation should be well covered.

HAVE THE AMBULANCES SAVED LIVES?

The impact of a coronary ambulance system on the community cannot be assessed satisfactorily. A major problem concerns the very high mortality from coronary disease: between 25% and 50% of men die from this cause.^{16 17} A scheme may therefore be useful and save many lives, yet have a small effect in statistical terms. Can we adduce evidence that lives have been saved by coronary ambulances? Critics can contend that defibrillation of patients suffering circulatory arrest during transit provides no evidence, for had the patients not been moved the crisis would not have occurred. This notion can be countered in part, for whatever the relative merits of home and hospital treatment,¹⁸ movement to hospital will always be necessary for most who become ill away from home or who have home circumstances which do not permit reasonable care. But we have a more compelling argument: our resuscitation ambulances provide effective treatment for some patients who collapse with unexpected circulatory arrest outside hospital. Of the 27 patients who were discharged over a two-year period after suffering ventricular fibrillation outside hospital, 16 (59%) had had this otherwise lethal arrhythmia before the ambulance arrived. That these patients at least were saved by the ambulances cannot seriously be doubted.

The prospects for success in patients already in ventricular fibrillation when the ambulance arrives have been greatly increased by the availability of portable equipment and immediate monitoring through defibrillator paddles. We have been surprised that many patients now recover though pupils were dilated and all respiratory movements had ceased before effective treatment was available. Cobb *et al* in Seattle⁴ were encouraged by similar early results to concentrate more resources on this aspect of resuscitation. Methods for summoning help were well publicised, external cardiac massage was taught extensively within the community, and paramedical (fire department) units were strategically placed throughout the city. Over two years 595 patients were found in ventricular fibrillation, and no less than 23% became long-term survivors.

Many people in Brighton do not call 999 when they witness an unexpected collapse even when a telephone is available. Few understand the principles of cardiac massage, and the climate of opinion does not always encourage attempts to set up training schemes.¹⁹ Greater public awareness is needed before resuscitation ambulances in Britain can realise their full potential for saving life.

One other difficulty must be mentioned. Out-of-hospital resuscitation does not permit discretion in patient selection and defibrillation of the very elderly and infirm may not always be appropriate. Few patients of this type survive to be admitted.

DELAY BEFORE REACHING HOSPITAL

Out-of-hospital resuscitation is not the only yardstick of success for coronary ambulance systems. A second and perhaps even more important benefit concerns the reduction in delay before admission of patients with acute myocardial ischaemia. The present median interval of less than two hours from the onset of major symptoms to arrival at hospital for patients brought by special ambulance contrasts with an overall delay of more than eight hours in early 1971. Since mortality from arrhythmias is greatest in the few hours after onset of infarction, more successful defibrillations are achieved than previously. From January 1974 to December 1975, 63 patients were discharged after episodes of cardiac arrest in hospital. We do not know how often fibrillation was prevented by early treatment of premonitory arrhythmias and routine treatment in hospital, nor can we assess any reduction in the incidence of cardiogenic shock or limitation of infarct size³ consequent on early admission. The indirect benefits accruing from the resuscitation ambulance system cannot be easily quantified.

We have no evidence to suggest that anxiety, and therefore the risk of serious arrhythmias, is increased by the special equipment. The incidence of primary ventricular fibrillation immediately before or during transit—eight cases in 1974 and three in 1975—represents 1% of patients with myocardial infarction or coronary insufficiency carried in the ambulances over the two years. Even if all 11 patients had died they would have accounted for only 8% of our coronary deaths, compared with similar figures of 11%²⁰ and 13%²¹ quoted previously for mortality during transit. Great emphasis is placed on the importance of reassurance. Patients are moved slowly and carefully, and the purpose of monitoring is explained; all but two of the 100 patients we surveyed claimed they found the extra equipment reassuring. This subjective evaluation was supported by a limited study we made of changes in heart rate during transit, which were surprisingly small.

We cannot tell from our data if atropine and lignocaine affected the incidence of serious ventricular arrhythmias. The apparent success of lignocaine in suppressing ventricular extrasystoles in most patients disagrees with findings in other studies,²²⁻²³ and further observations are being made on this point. We believe that the skill of the ambulancemen in dealing with respiratory arrest complicating ventricular fibrillation contributed to the successful resuscitation of several patients who had collapsed before an ambulance was summoned. We also recommend that

more than one special vehicle should be available if results are to be optimal, since the quality of information given in a 999 call is usually inadequate to permit reliable triage by ambulance control.¹⁴

OPEN ADMISSION

An effective coronary ambulance system implies some type of open admission, which can throw an undoubted strain on limited hospital resources. Initially we offered open admission to younger patients only (under 55) but selection by age cannot and should not be applied rigidly. We have sought to minimise the impact of our policy in three ways. Firstly, we emphasise at every opportunity that admission should be considered principally when infarction is suspected or diagnosed within two or three hours of the event: hospital care is unlikely to be of benefit overall for apparently uncomplicated cases diagnosed relatively late. Secondly, we have increasingly adopted a policy of early discharge. Median stay in our hospital is now eight days for all patients admitted to the coronary care unit (1975 figures). Mortality from primary ventricular fibrillation or extension of muscle necrosis remains relatively high for several months after infarction and some patients will always die soon after discharge; but better understanding of the factors that influence prognosis²⁵ and knowledge of the indications for prophylactic antiarrhythmic drugs²⁶ have given a more rational basis to our policy. Thirdly, we take advantage of the coronary ambulance system by discharging more quickly than previously those patients with coronary insufficiency who can summon help in the event of prolonged pain. As a result of these policies, the hospital bed occupancy for patients admitted to the coronary unit fell by 12% from 1974 to 1975.

We believed at the outset that a problem inherent in our scheme might be the liaison between the ambulancemen and the doctors and nurses with whom they came into contact. In the event, general practitioners have been enthusiastic in their support of the ambulances and relationships with junior hospital staff have usually been excellent. Some difficulties did occur in the accident and emergency department, but the practice of encouraging nurses to travel from time to time in ambulances and ambulance attendants to observe in the accident and emergency area has resulted in a more widespread understanding of the problems that exist on both sides of the hospital door and better relationships throughout.

Conclusions

As with other systems, the small risk of death during transit from primary ventricular failure should be eliminated by our coronary ambulance system. The interval between emergency calls and arrival of the ambulance is kept to a minimum, and response times of less than five minutes can be commonplace for ambulances operating within circumscribed areas. This allows prospects for recovery even for patients who collapse and are found in ventricular fibrillation on arrival of the ambulance. Because no extra staff have been employed the cost is relatively small and at least commensurate with the returns measured by improved survival and quality of general patient care. Although intravenous drug treatment must be limited to relatively few safe agents, experienced ambulance attendants can become extraordinarily proficient at difficult practical procedures such as intubation and injection into collapsed veins. We believe that the Brighton experiment confirms the feasibility of a two-tier ambulance system with some attendants trained as skilled technicians in resuscitation.

Our task has been made easy by the enthusiasm and skill of the ambulance staff. We are indebted to Mr David Low for his help with computer records. The Brighton experiment has been supported by grants from the British Heart Foundation and the South-east Thames Regional Health Authority. We also received generous donations from

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Association of HLA-A9 and HLA-B5 with Buerger's disease

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Summary

Eighteen patients who satisfied stringent criteria for the diagnosis of Buerger's disease, healthy controls, and patients with atherosclerosis were tested for various HLA antigens. The incidence of HLA-A9 and HLA-B5 was significantly greater among those with Buerger's disease. This finding supports the concept that Buerger's disease is a distinct clinicopathological condition.

Introduction

Since Buerger originally described the clinicopathological disorder that bears his name,¹ considerable doubt has been cast on its existence as a disease separate from early-onset atherosclerosis of a peripheral distribution.²⁻³ Support for its existence as a separate disease has been given, however, by clinical, epidemiological, and arteriographic studies.⁴⁻⁸ As the disease is more common in certain ethnic groups^{9,10} and within families,¹¹⁻¹⁴ we investigated the histocompatibility types of all patients reported to us as having Buerger's disease on Merseyside.

Patients and methods

In response to a letter written to consultants with an interest in peripheral vascular disease 28 patients with Buerger's disease were

referred for study. Their case records and arteriograms were reviewed independently. The clinical criteria of Mozes *et al*⁸ were applied. These require that in addition to ischaemic symptoms in the leg, the patient must show at least two "systemic manifestations"—migrating phlebitis, Raynaud-like phenomena in the hands or feet, or involvement of the hands. The radiographic criteria of McKusick *et al*⁴ were used to evaluate the arteriograms. Routine investigations included full blood count, measurement of erythrocyte sedimentation rate, urea and electrolyte estimation, liver function tests, Rose-Waaler test, antinuclear antibody test, and cryoglobulin and cryofibrinogen estimation. Tissue typing was performed according to the method of Dausset¹⁵ using fresh lymphocytes and 26 standard antisera (National Tissue Typing Reference Laboratory, Bristol). To compare HLA frequencies 616 healthy blood donors and 91 patients with atherosclerotic disease of the leg attending the same vascular clinic were

HLA types in patients with Buerger's disease, patients with atherosclerotic disease, and controls

HLA antigens	No of patients with Buerger's disease (n = 18)	No of patients with atherosclerotic disease (n = 91)	No of controls (n = 616)
<i>1st segregant series</i>			
A1	5	26	195
A2	7	36	266
A3	3	20	148
A9	9*	11	83
A10	1	7	40
A11	2	7	56
A28	1	5	46
AW29	0	0	NT
AW32	0	1	NT
19 Cap	0	0	NT
<i>2nd segregant series</i>			
B5	15†	3	37
B7	3	20	151
B8	4	22	157
B12	0‡	27	185
B13	1	3	18
B14	1	4	46
B17	1	6	46
B27	1	4	40
BW5	1	8	49
BW10	1	6	56
BW15	0	5	40
BW16	0	0	NT
BW18	0	0	NT
BW21	0	0	NT
BW22	0	1	NT
TY	0	0	NT

* $\chi^2 = 15.98$; $P < 0.001$. † $\chi^2 = 128.81$, $P < 0.001$. ‡ $\chi^2 = 6.25$; $P < 0.09$. NT = Not tested.

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