Effects of sciatic nerve transection on glucose uptake in the presence and absence of lactate in the frog dorsal root ganglia and spinal cord

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(With 3 figures)

Abstract

Frogs have been used as an alternative model to study pain mechanisms because the simplicity of their nervous tissue and the phylogenetic aspect of this question. One of these models is the sciatic nerve transection (SNT), which mimics the clinical symptoms of “phantom limb”, a condition that arises in humans after amputation or transverse spinal lesions. In mammals, the SNT increases glucose metabolism in the central nervous system, and the lactate generated appears to serve as an energy source for nerve cells. An answerable question is whether there is elevated glucose uptake in the dorsal root ganglia (DRG) after peripheral axotomy. As glucose is the major energy substrate for frog nervous tissue, and these animals accumulate lactic acid under some conditions, bullfrogs Lithobates catesbeianus were used to demonstrate the effect of SNT on DRG and spinal cord 1-[14C] 2-deoxy-D-glucose (14C-2-DG) uptake in the presence and absence of lactate. We also investigated the effect of this condition on the formation of 14CO2 from 14C-glucose and 14C-L-lactate, and plasmatic glucose and lactate levels. The 3-O-[14C] methyl-D-glucose (14C-3-OMG) uptake was used to demonstrate the steady-state tissue/medium glucose distribution ratio under these conditions. Three days after SNT, 14C-2-DG uptake increased, but 14C-3-OMG uptake remained steady. The increase in 14C-2-DG uptake was lower when lactate was added to the incubation medium. No change was found in glucose and lactate oxidation after SNT, but lactate and glucose levels in the blood were reduced. Thus, our results showed that SNT increased the glucose metabolism in the frog DRG and spinal cord. The effect of lactate on this uptake suggests that glucose is used in glycolytic pathways after SNT.

Keywords: peripheral nerve lesion, 1-[14C] 2-deoxy-D-glucose, 3-O-[14C] methyl-D-glucose.

Efeito da secção do nervo isquiático sobre a captação de glicose na presença e ausência de lactato em gânglio da raiz dorsal e medula espinhal de rã

Resumo

As rãs são usadas como modelos experimentais alternativos no estudo da nocicepção, tanto pela simplicidade do seu tecido nervoso como por permitirem uma abordagem filogenética sobre o tema. Um desses modelos é a secção do nervo isquiático (SNI), o qual simula os sintomas clínicos do “membro fantasma”, uma condição que ocorre nos humanos após amputação ou secção completa da medula espinhal. Em mamíferos, a SNI aumenta o metabolismo da glicose no sistema nervoso central, e o lactato é uma fonte energética para as células nervosas. Porém é desconhecido se essa é a situação em gânglio da raiz dorsal (GRD). Como a glicose é o principal substrato energético para o tecido nervoso de rãs, e a concentração plasmática de lactato está aumentada nesses animais em distintas situações, a rã-touro Lithobates catesbeianus foi usada para demonstrar os efeitos da SNI sobre a captação de 1-[14C] 2-deoxi-D-glicose (14C-2-DG), na presença e ausência de lactato, em GRD e medula espinhal. Foram demonstrados ainda os efeitos dessa condição experimental sobre a formação de 14CO2, a partir de 14C-glicose e 14C-L-lactato, e a concentração plasmática de glicose e lactato. A captação de 3-O-[14C] metil-D-glicose (14C-3-OMG) foi usada para demonstrar a relação tecido/meio estável da glicose nessas condições. A captação de 14C-2-DG aumentou três dias após a SNI, sem qualquer alteração na captação de 14C-3-OMG. O aumento foi reduzido quando o lactato foi acrescentado ao meio de incubação. A taxa de oxidação da glicose e do lactato não modificou após SNI, mas houve redução na concentração plasmática de glicose e lactato. Assim, a SNI aumenta o metabolismo da glicose no GRD e medula espinhal de rãs. Os efeitos do lactato sobre essa captação sugerem o uso da glicose na via glicolítica após a SNI.

1. Introduction

The sciatic nerve transection (SNT) model mimics the clinical symptoms of “phantom limb”, a condition that arises in humans after amputation or transverse spinal lesions (Klusáková and Dubový, 2009). Studies have demonstrated that this condition causes structural, electrophysiological, molecular and metabolic changes in mammalian dorsal root ganglia (DRG) cells and spinal cord. These changes include progressive loss of cells (Olivera, 2001; Jiang and Jakobsen, 2010), proliferation and activation of satellite glial cells (Hanani, 2005) and reorganisation of the metabolic priorities of neural cells (Enes et al., 2010). There is evidence that the transection of facial and hypoglossal nerves produces a significant increase in glucose utilisation in motor nuclei of these nerves in rats (Kreutzberg and Emmert, 1980). Changes in glucose uptake also occurred in rat auditory pathways after bilateral ablation of the cochlea (Ahn et al., 2004).

An answerable question is whether there is elevated glucose uptake in the dorsal root ganglia (DRG) after peripheral axotomy.

One consequence of the SNT is an increase in vesicular glutamate transporter-2 (VGLUT2) in the dorsal root fibres of rats (Brumovsky et al., 2007). Studies have demonstrated that when more glutamate is released, more lactate is also generated, which may serve as an energy source for nerve cells (Schurr et al., 1999; Schurr and Payne, 2007; Barros and Deitmer, 2010; Schurr and Gozal, 2012).

Amphibians have been used as an alternative model to study pain mechanisms (Stevens, 2004; Stevens et al., 2007; Stevens et al., 2009; Coble et al., 2011; Ohkita et al., 2012; Saito et al., 2012), for several reasons. Stevens (2004) noted that the use of these animals provides a phylogenetic perspective on the mechanisms of pain research. Other aspects include the simplicity of the amphibian central nervous system and the economic advantage of using these animals. In addition, the metabolic changes are much slower in frog brain than those found in the mammalian brain (McDougal et al., 1968). Thus, frog nervous tissue offers a unique model to examine the relationship between SNT and glucose metabolism.

The American bullfrog Lithobates catesbeianus is an aquatic amphibian native to the United States, which was imported into Brazil during the early 1930s and has been raised in this country ever since (Rocha and Branco, 1998). The ease of acquiring specimens of L. catesbeianus has allowed us to use this animal as an experimental model in our studies. One of the experimental situations is the SNT. In previous studies, members of our laboratory have demonstrated changes in different neurotransmitters and neuropeptides after SNT. Many of these alterations share similarities with those observed in mammals (Partata et al., 2002; Guedes et al., 2004a, b). As glucose has been considered the major energy substrate for the frog brain (McDougal et al., 1968), glucose transporters (Glut) types 1 and 3 are found in the nervous tissue of these animals (Rigon et al., 2013) and they accumulate lactic acid under some conditions (Warren and Jackson, 2005). Therefore we used frogs to demonstrate the effect of SNT on frog DRG 1-[14C] 2-deoxy-D-glucose ([14C]-2-DG) uptake in the presence and absence of lactate. In addition, the formation of [14C]CO2 from [14C]-glucose and [14C] L-lactate, and elevated glucose and lactate plasma levels after SNT were demonstrated. The uptake of 3-O-[14C] methyl-D-glucose ([14C]-3-OMG) was used to demonstrate the steady-state tissue/medium glucose distribution ratio under these conditions. All these parameters were also analysed in the lumbar sacral spinal cord, where most of the afferent fibres of the sciatic nerve enter and the motor neurons of this nerve are located (Penicnack and Dunlap, 1962; Sutherland and Nunnemacher, 1974). We used [14C]-2-DG because this molecule is a glucose analogue that is incorporated into neural tissue by the same pathways, and at the same rate, as glucose, but it is not completely metabolised and therefore becomes trapped in the cell as deoxyglucose-6-phosphate and is not further metabolised by the glycolytic pathway. All experiments were performed three days after SNT, because previous studies demonstrated that functional changes in frog nervous tissue are already present three days following axotomy (Partata et al., 2002; Guedes et al., 2004a, b).

2. Material and Methods

2.1. Experimental animals

Specimens of adult male bullfrogs Lithobates catesbeianus weighing 100-200 g were obtained from RANASUL (Imbé, RS). Upon arrival at the laboratory they were housed in cages with water and kept under natural light at 12-25°C temperature. The animals were fed ad libitum with specific food which was offered on a vibration plate to move the pellets. The animals remained in these laboratory conditions for at least 2 weeks before they were used in the experiments. The frogs were divided into three experimental groups (six animals/group): naive (animals that did not undergo surgical manipulation), Sham (animals in which all surgical procedures to expose the sciatic nerve were used except transection of this nerve) and SNT (animals in which the sciatic nerve was exposed and transected). For surgical procedures, frogs were anaesthetised with prilocaine (0.1 ml/100 g body weight). In the SNT group, the right sciatic nerve was exposed and transected approximately 5 mm distal to the sciatic notch. In all animals the wound was closed and the animals were killed 3 days after the procedure. The results reported here were obtained between April and September. The experimental protocol followed the NIH Guide for the Care and Use of Laboratory Animals (NIH publication 85-23 revised 1985). All efforts were made to minimise the number of animals used and their suffering. The experimental protocol was approved by the graduate committee of the Institute of Basic Health Sciences, Federal University of Rio Grande do Sul.

2.2. Glucose uptake

Ganglia were excised from naive, sham and transected frogs over a period of 3 min and rapidly transferred to sterile chilled Ringer’s solution. The Ringer’s solution was...
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2.3. Formation of 14CO2

in flasks sealed with rubber caps at 25°C, with constant
lesion) and the lumbosacral spinal cord were incubated
initially described. This value was chosen for lactate
plus 10 mM lactate for 60 min under the same conditions
The tissues were incubated with 0.15 µCi 14C-2-DG
separated ipsilaterally and contralaterally to the nerve
ganglia obtained from the same spinal-cord segment were
incubated, separately, under the above conditions. The
lumbosacral spinal cord were quickly dissected out and
Three days after the peripheral injury, the DRG and

DG or 14C-3-OMG for 60 min under the same conditions

Incubation in the presence of 0.15 µCi of 3-O-[14C] methyl-D-glucose (14C-3-OMG) (53 mCi/mmol, Amersham) was used in the same conditions to determine the steady-state tissue/medium glucose distribution ratio (Dienel et al., 1997). Incubations were performed in a Dubnoff incubator with an atmosphere of O2:CO2 (95:5, v/v). Following the incubations, the tissues were removed from the medium, rinsed twice in cold frog Ringer’s solution (without radiolabelled products), blotted on filter paper and immediately transferred to screw-cap tubes containing 1 ml of distilled water, and alternately frozen and boiled three times. Aliquots (100 ml) of this solution and of the incubation medium were used for radioactivity counts in toluene-TritonX-100 (2:1, v/v) -0.4% PPO - 0.01% POPO. Radioactivity was measured in a liquid scintillation spectrometer (LKB Wallac scintillation counter). Results were expressed as tissue/medium (T/M) rate, i.e., dpm/ml of tissue fluid divided by dpm/ml of incubation medium.

To facilitate visualisation of the sequence of experiments, they are described separately below, in the sequence in which they were performed.

Experiment 1: Time curve. DRG and spinal cord from naive frogs were incubated under the above conditions with 0.15 µCi of 14C-2-DG or 14C-3-OMG for 5, 15, 60 and 120 min.

Experiment 2: Effects of SNT on 14C-2-DG uptake. Three days after the peripheral injury, the DRG and lumbosacral spinal cord were quickly dissected out and incubated, separately, under the above conditions. The ganglia obtained from the same spinal-cord segment were separated ipsilaterally and contralaterally to the nerve lesion. The tissues were incubated with 0.15 µCi 14C-2-DG or 14C-3-OMG for 60 min under the same conditions initially described.

Experiment 3: Effects of lactate on 14C-2-DG uptake. The tissues were incubated with 0.15 µCi of 14C-2-DG plus 10 mM lactate for 60 min under the same conditions initially described. This value was chosen for lactate because it was used in other studies with the ganglion (Larrabee, 1980, 1996).

2.3. Formation of 14CO2

DRG obtained from the same spinal cord segment (separately, ipsilaterally and contralaterally to the nerve lesion) and the lumbosacral spinal cord were incubated in flasks sealed with rubber caps at 25°C, with constant
shaking, in 1 ml of frog Ringer’s solution, pH 7.4. To this incubation medium were added 0.15 µCi [U-14C] L-lactate (108.30 mCi/mmol, Amersham) plus 10 mM of unlabelled lactate or 0.15 mCi [U-14C] glucose (115.00 mCi/mmol, Amersham) plus 10 mM glucose (Torres et al., 2001). Incubation was conducted in an atmosphere of O2:CO2 (95:5, v/v) for 60 min. After addition of the unlabelled lactate or glucose, the pH of the incubation medium was determined. A saturating lactate or glucose concentration was used for CO2 production. 3MM Whatman papers were placed into glass wells inserted in the rubber stoppers of the flasks. Incubation was stopped by adding 0.2 ml of 50% TCA through the rubber cap. Then, 0.2 ml of 2 M NaOH was injected into the central wells to trap 14CO2. These were small glass wells placed inside the flasks and above the level of the incubation medium. The flasks were shaken for a further 60 min at 25°C to trap 14CO2, after which the contents of the centre well were transferred to vials containing toluene-TritonX-100 (2:1, v/v) - 0.4% PPO - 0.01% POPO and assayed for CO2 radioactivity in a liquid scintillation counter. The values of 14CO2 production were expressed as mmol of 14C-L-lactate or 14C-glucose converted to 14CO2, mg of tissue⁻¹ . h⁻¹ of incubation.

2.4. Determination of plasma lactate and glucose

Samples of plasma were obtained from naive and transected frogs. Glucose blood concentration was determined by the glucose oxidase method with a Labtest kit (Brazil), and blood lactate was determined with a Bioclin kit (Quibasa, Brazil). Values of glucose and lactate were expressed in mmol/L.

2.5. Statistical analysis

The results obtained from frog ganglia with peripheral lesion were compared between the ipsilateral and contralateral ganglia and with naive and sham ganglia. For the spinal cord, the results were compared among naive, sham and injured frogs. Data were analysed by one-way ANOVA followed by Tukey’s post hoc test. The results for plasma were analysed by an independent Student’s t test. The significance level was P<0.05. All tests were performed with the Statistical Package for the Social Sciences, version 13.0 (SPSS).

3. Results

3.1. Glucose uptake and 14CO2 formation

In DRG and spinal cord, the 14C-2-DG uptake was not affected by the incubation time. The 14C-3-OMG uptake showed no change in DRG and spinal cord (Table 1).

In spinal cords from naive animals, the 14C-2-DG uptake was 3.5 times higher than in DRG (Figure 1). This uptake changed in DRG when lactate was added to the incubation medium. Although 14C-2-DG uptake decreased by around 36% in DRG of naive animals, it remained the same in the spinal cord (Figures 1a, b, c).

The 14C-2-DG uptake was increased in DRG three days after SNT. The increase of 14C-2-DG uptake was 223% and 141% in the ipsilateral and contralateral DRG,
Thus, the frog DRG and spinal cord were able to transport condition reduced the blood levels of lactate and glucose. and lactate oxidation after SNT, but this experimental incubation medium. No change was found in glucose DG uptake was smaller when lactate was added to the in 14C-2-DG uptake, but no change in 14C-3-OMG uptake in this uptake in DRG and spinal cord from naive frogs, showing that this effect is specific to SNT. In the DRG, the increase in 14C-2-DG uptake caused by SNT was smaller in the presence of lactate in the incubation medium. This increase was approximately 58% in the ipsilateral and contralateral ganglia compared to those of the naive group (Figure 1c). The values of 14C-2-DG uptake in the presence of lactate decreased by around 57% and 46% in the ipsilateral and contralateral ganglia, respectively, compared to ganglia from SNT frogs (Figures 1a, c). Similarly, 14C-2-DG uptake in the spinal cord was also reduced in the presence of lactate, by about 50% compared to the naive group (Figure 1c), but by 59% compared to the spinal cords from SNT frogs (Figures 1b, c).

Both DRG and spinal cord use lactate, but the DRG rate was about 100 times higher than in the spinal cord (Figure 2a). Sciatic nerve transaction failed to induce any significant changes in the formation of 14CO2 from 14C-L-lactate in these tissues (Figure 2a). The rate of 14C-glucose oxidation did not change after SNT (Figure 2b).

3.2. Lactate and glucose plasma levels

SNT significantly decreased lactate and glucose plasma levels, but the reduction was greater for lactate than for glucose. Lactate levels decreased by about 65% (Figure 3a), while glucose levels decreased by about 39% (Figure 3b).

4. Discussion

Our results demonstrated that SNT induced an increase in 14C-2-DG uptake, but no change in 14C-3-OMG uptake in the frog DRG and spinal cord. The increase in 14C-2-DG uptake was smaller when lactate was added to the incubation medium. No change was found in glucose and lactate oxidation after SNT, but this experimental condition reduced the blood levels of lactate and glucose. Thus, the frog DRG and spinal cord were able to transport 14C-2-DG efficiently. The absence of changes in 3-OMG uptake under our experimental conditions demonstrates the steady-state tissue/medium glucose distribution ratio during the incubations. In turn, the lack of change in 14C-2-DG uptake over time may be a function of the animal species studied. The uptake of 14C-2-DG by the turtle thyroid incubated at 25°C increased markedly at 240 min (Machado et al., 1991).

Interestingly, 14C-2-DG transport decreased when lactate was added to the incubation medium. It has been demonstrated that the perineurium surrounding the frog DRG contains fewer cell layers and more gaps in these layers than the mammalian perineurium (Matsumoto and Rosenbluth, 1988). According to these authors, these characteristics increase the susceptibility of DRG to circulating molecules and allow trophic factors, hormones and nutrients to reach the ganglion cells more readily. This characteristic would contribute to higher utilisation of lactate in the DRG than the spinal cord. In this tissue, the blood-brain-barrier has many of the properties of a tight epithelium, including the presence of tight junctions and specific transport mechanisms (Abbott, 2005). The more-developed barrier in the spinal cord may limit the use of lactate by this tissue. By using less lactate, the spinal-cord tissue appears to depend principally on glucose, which explains the elevated 14C-2-DG uptake and the absence of change in the uptake when lactate was added to the incubation medium. Higher glucose utilisation by the spinal cord than the DRG also occurs in rats (Kadekaro et al., 1985). The use of lactate as an energy substrate by the frog DRG also concords with observations from studies of mammals and non-mammals. Previous studies showed a preferential use for lactate in avian, mammalian and human neuronal oxidative metabolism (Larrabee, 1980, 1996; Bouzier-Sore et al., 2003, 2006; Pellerin and Magistretti, 2012).

After SNT, we found an increase in 14C-2-DG uptake in the frog DRG and lumbosacral spinal cord. A similar result was observed in mammalian cephalic nerves after peripheral lesion (Kreutzberg and Emmert, 1980; Singer and Mehlert, 1980; Mao et al., 1993; Moreno-Flores et al., 1997; Moran and Graeber, 2004; Gómez et al., 2011). Since 14C-2-DG is a glucose analogue that is incorporated into neural tissue by the same pathways, and at the same rate, as glucose, the increase in 14C-2-DG uptake possibly reflects the increased energy demand to meet the metabolic requirements of

Table 1. Uptake of 1-[14C] 2-deoxy-D-glucose and 3-O-[14C] methyl-D-glucose by dorsal root ganglia (DRG) and spinal cord (SC) from naive frogs.

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>1-[14C] 2-deoxy-D-glucose</th>
<th>3-O-[14C] methyl-D-glucose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DRG</td>
<td>SC</td>
</tr>
<tr>
<td>5</td>
<td>0.22 ± 0.06</td>
<td>0.22 ± 0.02</td>
</tr>
<tr>
<td>15</td>
<td>0.22 ± 0.02</td>
<td>0.26 ± 0.03</td>
</tr>
<tr>
<td>60</td>
<td>0.22 ± 0.04</td>
<td>0.47 ± 0.02</td>
</tr>
<tr>
<td>120</td>
<td>0.25 ± 0.05</td>
<td>0.74 ± 0.08</td>
</tr>
</tbody>
</table>

These tissues were incubated at 25°C for different times and were processed as indicated under Materials and Methods. Data are given as means ± SEM. Results are expressed as tissue/medium (T/M) rate, i.e., dpm/ml of tissue fluid divided by dpm/ml of incubation medium. No significant difference was found (one way ANOVA).
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In mammals, glucose incorporation into neurons or phosphorylation of glucose appears to be one of the earliest changes in metabolism affected by the signal for regeneration (Kreutzberg and Emmert, 1980; Singer and Mehler, 1980; Mao et al., 1993; Moreno-Flores et al., 1997).

After SNT, the DRG 14C-2-DG uptake was decreased when lactate was added to the incubation medium. A similar response also occurred in the spinal cord. Interestingly, the conversion of 14C-L-lactate and 14C-glucose to 14CO2 did not change after SNT in these tissues. This lack of change may be due to glycolysis. The rise in 14C-2-DG uptake with SNT, but not CO2 production, suggests that the cells may be producing lactate from the glucose metabolised, which explains, in part, the low oxidation rate of glucose. The higher lactate oxidation may result from the efflux of lactate into a much larger volume, driven by glycolysis. It has been demonstrated that neurons produce lactate from glucose, despite the presence of lactate in the extracellular space and its simultaneous utilisation as an oxidative

Figure 1. Uptake of 1-[14C] 2-deoxy-D-glucose (A and B) and 1-[13C] 2-deoxy-D-glucose plus lactate (C) by dorsal root ganglia (A) and spinal cord (B) from naive, sham and transected frogs. The tissues were incubated at 25°C and processed as indicated in Materials and Methods. Data are expressed as means ± SEM. (n= 6/group). Results are expressed as the tissue/medium (T/M) rate, i.e., dpm/ml of tissue fluid divided by dpm/ml of incubation medium. (a) indicates significant difference compared with naive and sham groups; (b) indicates significant difference compared to naive group (P<0.05, one-way ANOVA followed by Tukey’s post hoc test). IPSI, ipsilateral; CL, contralateral; SNT, sciatic nerve transection.

Figure 2. Formation of 14CO2 from [U-14C] L-lactate (A) and 14C-glucose (B) by dorsal root ganglia (DRG) and spinal cord from naive and transected frogs. These tissues were incubated at 25°C and processed as indicated in Materials and Methods. Data are expressed as means ± SEM. (n= 6/group). Results are expressed as (A) mmol 14C-L-lactate converted to 14CO2, mg of tissue−1, h−1 of incubation and (B) 14CO2, mg of tissue−1, h−1 of incubation. No significant difference was found (one-way ANOVA). IPSI, ipsilateral; CL, contralateral; SNT, sciatic nerve transection.

After SNT, the DRG 14C-2-DG uptake was decreased when lactate was added to the incubation medium. A similar response also occurred in the spinal cord. Interestingly, the conversion of 14C-L-lactate and 14C-glucose to 14CO2 did not change after SNT in these tissues. This lack of change may be due to glycolysis. The rise in 14C-2-DG uptake with SNT, but not CO2 production, suggests that the cells may be producing lactate from the glucose metabolised, which explains, in part, the low oxidation rate of glucose. The higher lactate oxidation may result from the efflux of lactate into a much larger volume, driven by glycolysis.
peripheral nerves stimulate a marked increase in vascular permeability in the portion of the nerve distal to the lesion (Sparrow and Kiernan, 1981).

Interestingly, while the glucose/lactate ratio (mmol/mmol) was 1.2 in the plasma of naive frogs, it increased to 2.9 after SNT. This reduction in blood lactate levels may be related to muscle denervation. However, it has been demonstrated that denervation decreases the activities of succinate and lactate dehydrogenase in mammalian muscles, and down-regulates the expression of monocarboxylate transporters (Wilson et al., 1998; Juel and Halestrap, 1999). Another possibility may be the role of mineralised tissues of the frog in buffering lactic acidosis. The skeletal and endolymphatic calcium deposits function as buffers during anoxia and exercise-induced lactic acidosis in amphibians (Warren and Jackson, 2005). Additional studies should examine the relative contributions of these possible ways to reduce plasmatic lactate after SNT.

It might be assumed that the utilisation of plasma lactate is related to the anesthesia administered in the present study. However, although anesthesia does change hematological and cardiorespiratory parameters in the toad, they are recovered after 24 hours, and the blood lactate concentration does not change under these conditions (Andersen and Wang, 2002). Thus, the results of the present study are probably due to SNT and not to the anesthesia.

In conclusion, our results showed that SNT increases \(^{14}\text{C}-2\text{-DG} \) uptake. The increase in this uptake suggests high levels of functional activity of the frog DRG and spinal cord after SNT. Nevertheless, the amount of this increase was smaller in the presence of lactate. No change occurred in glucose and lactate oxidation after SNT, but glucose and lactate blood levels declined. Considering the effect of lactate on \(^{14}\text{C}-2\text{-DG} \) uptake, it can be speculated that the glucose may be supplying the glycolytic pathway. The similarities in the frog and mammalian physiological responses suggest that a similar situation may exist in mammals. However, further studies are necessary to extend out understanding of the role of lactate in DRG and spinal cord after SNT.

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References


Figure 3. Blood lactate (A) and glucose (B) in naive and transected frogs. Lactate and glucose levels were determined as indicated under Materials and Methods. Results are expressed in mmol/L. (a) indicates significant difference compared with naive group (P<0.05, one-way ANOVA followed by Tukey’s post hoc test). SNT, sciatic nerve transection.
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