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Relationships between thyroid status, tissue oxidative metabolism, and muscle differentiation in bovine fetuses

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Abstract

The temporal relationships between thyroid status and differentiation of liver, heart and different skeletal muscles were examined in 42 bovine fetuses from day 110 to day 260 of development using principal component analysis of the data. Plasma concentrations of reverse-triiodothyronine (rT_3) and thyroxine (T_4) increased during development from day 110 to day 210 or 260, respectively, whereas concentration of triiodothyronine (T_3) and hepatic type-1 5′-deiodinase activity (5′D1) increased from day 180 onwards. On day 260, high T_4 and rT_3 and low T_3 concentrations were observed together with a mature 5′D1 activity. Cytochrome-*c* oxidase (COX) activity expressed per mg protein increased at day 180 in masseter and near birth in *masseter*, *rectus abdominis* and *cutaneus trunci* muscles ($P < 0.05$). Significant changes in citrate synthase (CS) activity per mg protein were observed between day 110 and day 180 in the liver and between day 210 and day 260 in the liver, the heart and the *longissimus thoracis* muscle ($P < 0.05$). Muscle contractile differentiation was shown by the disappearance of the fetal myosin heavy chain from day 180 onwards. A positive correlation ($r > 0.47$, $P < 0.01$) was shown between thyroid status parameters (5′D1, concentrations of T_4 and T_3) and COX activity in muscles known to be oxidative after birth (*masseter*, *rectus abdominis*) but not in liver and heart, nor in muscles known to be glycolytic after birth (*cutaneus trunci*, *longissimus thoracis*). A similar correlation was found between thyroid parameters and CS activity in liver and *masseter*. Results indicate that elevation

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of plasma T_3 concentrations in the last gestational trimester could be involved in the differentiation of oxidative skeletal muscles.

Keywords: Bovine fetus; Thyroid hormone; Oxidative enzymes; Muscle differentiation; Principal component analysis

1. Introduction

Thyroid hormones (TH) play a crucial role in growth, development, and function of most vertebrate tissues, such as brain, bone, adipose tissue, and skeletal muscles [1]. They affect both tissue accretion and differentiation in the fetus by a combination of metabolic and non-metabolic mechanisms [2]. Thyroid hormones also exert critical effects on a variety of metabolic pathways, especially energy metabolism, and are key regulators of postnatal growth. Heart and skeletal muscles are important TH targets [3] especially the developing skeletal muscle [4]. In rat, TH control myosin heavy chain (MyHC) isoform transitions [5,6]. A role for TH is also suspected in coordinating the expression of contractile and metabolic muscular proteins [7].

Most studies relate to postnatal TH effects on experimental animals, mainly rodents. However, TH regulation of muscle development occurs as early as in the fetus for species which are mature at birth based on muscle biology, such as ruminants [8]. In fetal sheep, an intact thyroid gland is required for normal development and for biochemical and contractile differentiation of muscle masses [9].

Developmental and metabolic effects of TH are mediated by triiodothyronine (T_3), which is mainly produced by peripheral 5′-deiodination of thyroxine (T_4) [10]. However, the mechanisms of a TH action during fetal development of muscles are poorly documented although local interactions with the activity of the somatotrophic axis have been shown [11].

In this study, we investigated the influence of TH on tissue differentiation (heart, liver and skeletal muscles). We have examined temporal relationships between thyroid status, tissue oxidative capacity, and muscle differentiation in bovine fetuses during the two last trimesters of gestation. For this purpose, we have applied a multivariate analysis procedure [12].

2. Materials and methods

2.1. Animals and tissue samples

This study was carried out as part of a research program approved by the "Institut National de la Recherche Agronomique" (INRA, France) Ethical Committee. The study included 33 fetuses of comparable chronological age collected at day 110 (111.5 ± 6.5; $n = 6$), 180 (181.7 ± 5.9; $n = 7$), 210 (207.8 ± 4.8; $n = 10$), and 260 (259.6 ± 2.5; $n = 10$)